REPORT

—OF THE—

FIRST ☆ ANNUAL ☆ MEETING

—OF THE—

ILLINOIS SOCIETY

—OF—

ENGINEERS AND SURVEYORS,

—HELD AT—

CHAMPAIGN, ILL., FEB. 10, 11 AND 12,

1886.

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CONSTITUTION AND BY-LAWS

OF THE

Illinois Society of Engineers and Surveyors.

CONSTITUTION.

I.—NAME.

This Association shall be called the Illinois Society of Engineers and Surveyors.

II.—OBJECT.

The objects of this Association shall be the encouragement of professional improvement and good fellowship among its members by meetings for the presentation and discussion of papers on scientific or other topics and the discussion of such other subjects as may be of interest to its members; the publication of such parts of its proceedings as may be deemed expedient; and the collection of books, maps or other articles of value to the engineering profession.

III.—MEMBERS.

Sec. 1.—Any practical surveyor, civil or other engineer in good standing may become a member of this society.

Sec. 2.—Any person interested in engineering improvement or scientific study may become an associate member of this society with the same privileges as members.

Sec. 3.—Any person may be made an honorary member by a unanimous vote of the society.

IV.—OFFICERS.

Sec. 1.—The officers of this society shall be a President, a Vice-President, an Executive Secretary, a Recording Secretary, a Treasurer, and an Executive Board of five members, two of whom shall be the President and the Executive Secretary, *ex-officio.* They shall hold their office for one year and until their successors are elected and qualified.

Sec. 2.—They shall be elected by ballot on the last day of each annual meeting, and their term of office shall begin at the close of said meeting.

Sec. 3.—The President, Vice-President, Secretaries and Treasurer shall perform the duties usually pertaining to their several offices. The Executive Secretary shall be the custodian of all property of the society, and shall deliver all such property to his successor, and shall make an annual report. The Recording Secretary shall record the proceedings and discussions of the meetings, and shall prepare a copy of them for publication, which he shall transmit to the Executive Secretary. The Treasurer shall give bond with two approved sureties to such amount as may be required from time to time by the Executive Board, and his bond when approved by said board shall be copied on the journal of the society and deposited with the Secretary. He shall pay only such orders as have been signed by the President and Executive Secretary and shall make an annual report of all receipts and expenditures and shall deliver all the society's books and money in his possession to his successor.

Sec. 4.—The Executive Board shall audit the accounts of the Treasurer and determine the assessment per member for the following year immediately before each annual meeting and make annually a report to the society. They shall arrange the programme of exercises for each annual meeting and shall have a general care over the affairs of the society, and shall act for the society in all general matters between the annual meetings. No moneys shall be expended without a vote of the Executive Board.

Sec. 5.—There shall be appointed at each annual meeting seven standing committees of three members each, whose duty it shall be during the year to collate such facts, figures, and experiments of interest in their respective departments as may be brought to their notice, and make at least one formal report to the society at the annual meeting following their appointment. The committees shall be designated as follows:

a—The Legislative and Judiciary Committee.

b—Committee on Land Drainage and Public Highways.

c—Committee on Land and City Surveying.

d—A general Committee of Engineering.

e—Committee on Mining Engineering.

f—Committee on Sanitary Engineering and Water Supply.

g—Committee on Instruments, Blanks and Records.

V.—MEMBERSHIP.

Sec. 1.—Any person desiring to become a member or associate member of this society shall fill out a blank application to be provided by the Executive Secretary, who shall present the same when filled out to the Executive Board, who shall examine the application and if satisfied that the applicant is eligible shall recommend him for membership at the same or next annual meeting. All applications shall be returned by the Executive Board to the Executive Secretary to be by him copied in a book provided for the purpose.

Sec. 2.—In the election, members shall vote by ballot, and five or more ballots in the negative shall exclude from membership. In case of non-election of any applicant no notice thereof shall be taken in the minutes.

Sec. 3.—On being elected the applicant shall sign the Constitution and By-laws and pay into the treasury an initiation fee of three dollars. If the initiation fee be not paid within three months from notice of election, said election shall be considered void. All members shall sign the Constitution and By-laws.

Sec. 4.—Whenever any person is elected a member, associate member, or honorary member the Executive Secretary shall immediately notify him by letter. No person shall be an honorary member unless he signify his acceptance of membership within six months from time of election. Honorary members shall not be liable for initiation fees or annual assessments.

Sec. 5.—Any member who shall neglect or refuse to pay any assessment for a period of three months after due notice by the treasurer, shall cease to be a member and his name shall be struck from the roll. He may be reinstated by the payment of the assessment standing against him and of all other assessments made up to the time of reinstatement.

Sec. 6.—Any member may for just cause be expelled from the society by a three-fourths vote of the active membership present at the annual meeting. All such action shall be taken in secret session. No public announcement shall be made of the fact.

VI.—PUBLISHING ANNUAL REPORTS.

The Executive Board, when so ordered by the society, shall compile and publish the annual report of the transactions of the society. They shall include in this report all items of general interest in the proceedings, and such other matter as may seem to them advisable.

VII.—COMPENSATION OF OFFICERS.

The society may provide for the compensation of its officers for their services whenever deemed advisable.

VIII.—AMENDMENTS.

All propositions for amendments of this Constitution shall be referred to the Executive Board who shall report to the society before final adjournment of the annual meeting and such amendment shall be declared adopted on a two-thirds vote, not less than fifteen members voting.

BY-LAWS.

I.—The annual meetings of this society shall be in such place as shall be determined by this society at each previous meeting and at such time in January as shall be determined by the Executive Board. The Executive Board shall notify each member of the society at least 20 days before the annual meeting.

II.—Ten members shall constitute a quorum for the transaction of business.

III.—The meetings of this association shall be governed by "Roberts' Rules of Order."

IV.—The order of business shall be as follows:

1—Call to order.
2—Roll call.
3—Address of the President.
4—Report of Secretary.
5—Report of Treasurer.
6—Report of Executive Board.
7—Report of Standing Committees.
8—Report of Special Committees.
9—Programme.
10—Election of Members.
11—Unfinished Business.
12—New Business.
13—Election of Officers.
14—Installation of Officers.
15—Reading of Minutes.
16—Adjournment.

V.—A record of all donations to the society whether in money, books, maps, models, or other articles of value, with the names of the donors, shall be entered by the Executive Secretary in a book provided for that purpose.

VI.—These By-laws may be amended by a two-thirds vote of the members present at any annual meeting.

PROCEEDINGS

OF FIRST ANNUAL MEETING OF

Illinois Society of Engineers and Surveyors,

—HELD AT—

Champaign, Illinois, February 10–13, 1886.

The following circular was sent to those civil engineers and surveyors in Illinois whose addresses could be obtained:

University of Illinois, School of Civil Engineering.

Champaign, Ill., Nov. 17, 1885.

Dear Sir: I wish to ask your opinion about the advisability of organizing a State Association of Engineers and Surveyors. There is such an organization in Indiana, Ohio, Michigan, Missouri, Connecticut and possibly other States; in each of these States they have an annual meeting, in the winter, which is largely attended, and at which papers are read by the members. Such meetings are valuable in several ways, as will readily suggest themselves to you on a moment's reflection, and have proved very popular wherever organized. Please let me know what you think of the desirability of such an organization.

I send a copy of this circular to a number of engineers and surveyors in different parts of the State, and if the number, or nature, of the replies warrant it, I will issue a second circular notifying all of the result, and ask for advice in reference to further arrangements, as to place and time of first meeting, programme, &c.

Promptness is requested, since at best considerable time will be consumed in the preliminary steps.

Yours very truly,

I. O. Baker, Prof. of Civil Engineering.

The replies to this were so favorable that a second and a third circular were issued, announcing the University of Illinois at Cham-

paign as the place, and Feb. 10, 1886, as the time for the meeting, and arranging a programme as far as possible. About thirty engineers and surveyors assembled at the University Wednesday, Feb. 10, 1886.

The following officers were chosen to serve during the first meeting of the society: *President*, Prof. I. O. Baker, of Champaign; *Vice-President*, Daniel Gordon, of Moline; *Secretary* and *Treasurer*, A. H. Bell, of Bloomington. A discussion of the objects of the society and of the best methods of organization followed. All agreed that the term "engineer" should be understood in its broad sense, and that to every engineer, whether civil, mining, mechanical or other, shall be accorded the privilege of membership. Mr. E. D. Shreve, delegate from the Ohio Society of Surveyors and Civil Engineers, and Mr. F. Hodgman, delegate from the Michigan Engineering Society, gave accounts of the manner in which their respective societies are conducted, and offered valuable suggestions. The programme for the meeting was arranged, and a committee was appointed to draft a constitution and by-laws.

At the evening session, S. A. Bullard, City Engineer of Springfield, read the paper on "Sewerage for Small Cities," which is given elsewhere. No detailed report of the discussion which followed was taken, but a brief summary is appended to the paper. Thomas B. Kyle, County Surveyor of Champaign County, gave a paper on "Land Surveying." A discussion on the relative merits of the compass and transit followed. "Municipal Engineering" was read by A. H. Bell, City Engineer of Bloomington, Ill. A summary of the discussion is also given.

The papers read Thursday morning were "Drainage Districts and the Construction of Drainage Canals," by A. H. Bell; "The Highest Attainment in Drainage," by E. D. Shreve, of Bucyrus, Ohio; and "Storage Reservoirs and their Effects on Climate and Navigation," by Daniel Gordon, of Moline, County Surveyor of Rock Island County. A record of the discussions of the papers of the day was made by C. G. Elliott. After the adjournment, a visit was made to the mechanical and architectural workshops of the University under the guidance of the Regent, Dr. S. H. Peabody. Universal praise of the shop work of the students as well as the conduct of the University in general was expressed.

Thursday afternoon the following papers were read: "Road Improvement," by C. G. Elliott, Drainage Engineer, of Tonica;

"Bridges," by A. C. Braucher, of Lincoln; and "Pile Foundations," by Fred J. Sager, of Marysville, Ohio, Chief Engineer of the Cleveland and Marietta R. R.

At the evening session, a communication from L. P. Morehouse. Secretary of Western Society of Engineers, to Prof. Baker, in reference to this society's affiliating with the Western Society of Engineers, was read and placed on file. The committee on constitution and by-laws reported, and the amended report was adopted as printed elsewhere. The following officers were elected for the ensuing year: *President*, Prof. I. O. Baker; *Vice-President*, Daniel Gordon; *Executive Secretary*, Prof. A. N. Talbot; *Recording Secretary*, S. A. Bullard; *Treasurer*, G. P. Ela; *Executive Board*, C. G. Elliott, A. H. Bell, D. L. Braucher, I. O. Baker, and A. N. Talbot.

Friday morning, C. W. Clark, late U. S. Assistant Engineer to Mississippi River Commission, read a paper on "Topographical and Related Surveys as Prosecuted by the Government." Warren R. Roberts read "The Subdivision of Fractional Sections." On account of lack of time, two papers by Z. A. Enos, of Springfield, were read only "by title," but were ordered published with the proceedings. W. D. Pence, delegate from the Civil Engineers' Club of the University of Illinois to the Civil Engineers' Convention at Cleveland, Ohio, made an address, reporting the action of the Cleveland convention and giving the aims of the movement to secure a change in the management of government public works. The proceedings of the Cleveland convention was ratified and the following committee on National Public Works was appointed: G. P. Ela, Bloomington, G. F. Wightman, Peoria, and A. C. Braucher, Lincoln. The Executive Board was instructed to publish a report of the proceedings, and to determine the place of the next annual meeting. It was also decided that charter members should pay the initiation fee as provided by the constitution. A motion was adopted that all who have been present at this meeting or who have by letter signified their desire to become members be considered charter members on their paying the fee. By a unanimous vote the thanks of the Society were given to Messrs. E. D. Shreve, of Bucyrus, Ohio, F. J. Sager, of Marysville, Ohio, and F. Hodgman, of Climax, Michigan, for their valuable assistance in organizing, and they were made honorary members of the society. Students L. Bush and W. R. Roberts were thanked for their kindness in testing chains and tapes brought by the members. Resolutions in special acknowledgement of the many kindnesses and

courtesies of the Regent of the University, Dr. Peabody, and of the Faculty and students were passed. A vote of thanks was given T. L. Johnson, representing J. W. Queen & Co., for his elaborate display of mathematical and surveying instruments. Resolutions expressing the appreciation of the energetic and successful efforts of Prof. I. O. Baker in taking the initiatory steps for organizing the Society and in arranging and conducting the meeting were adopted. A final adjournment was then made.

THE SEWERAGE OF SMALL CITIES.

By S. A. BULLARD, of Springfield.

The congregation of people in villages and cities and the consequent limited space occupied by each family necessitates the united action of the people to dispose of the refuse matters resultant from habitation.

The methods of disposing of this refuse matter in the country and sparsely settled towns, which to cities becomes so necessitous, are by vaults, cess-pools, earth closets and mechanical filtration. Vaults and cess-pools to be inoffensive must be at a distance from house or wells; earth closets must be carefully and regularly attended to, and filtration to be faultless must be in places full of growing vegetation. The use of any of these methods is not often practicable in larger villages or in cities, and yet many cities of larger growth have practically left the municipal question of drainage and the disposal of sewerage unsolved with an indifference that is startling.

From the Chief Engineer's report of the city of Cincinnati for the year 1882 we clip the following:

"At present but one-sixteenth of the territory of the city is sewered, or about one and one-half square miles, and seventy thousand of our population are afforded sewerage facilities, while two hundred thousand people and twenty-two and one-half square miles of territory within the city limits are not provided for any opportunity for sewerage."

From the report of the same official two years later (1884) we take the following:

"Attention is called to the invidious and criminal practice which is in vogue in several of the unsewered sections of our city, of discharging the contents of water-closets and sinks into natural water courses and standing pools. * * * * The filth debouched in this manner into dry runs and water courses, under the effects of a broiling sun soon festers and sends out its deadly vapors, poisoning and polluting the atmosphere and sowing the seeds of disease.".

In mentioning Cincinnati I do so not making any unkind distinction but as an illustration of the importance of this matter to cities and the results to be expected from the culpable neglect of municipal officials to give sufficient attention to proper sewerage facilities. In fact nearly all cities and villages have frequent illustrations in their very midst.

The surface or storm water to be taken from our streets is a matter of considerable importance in estimating the cost or laying the plans for the proper drainage of thickly populated districts. House drainage is regular and does not vary much in the course of the year, but surface drainage varies with the rainfall and sewers must have such capacity that they will carry off all usual storm water. In fact, if sewers are planned with ample capacity for taking off the usual storm water, that will usually be sufficient, for their capacity in this regard is never tested longer than a short time and the temporary suspension of the usual drainage for that period would have no evil results.

The capacity of a sewer depends on its size, fall, regularity of fall and the quality of the materials of construction as regards friction. The amount of fall for small sewers should not be less than two inches and usually not more than eighteen inches per 100 feet; larger ones may have less. A very small amount of fall tends to stagnation and the accumulation of filth in the sewer which may have to be removed by mechanical means, while if the fall be excessive there is a liability to wash away the material of the sewer itself. If the line of the sewer is so situated that not so much fall as two inches per hundred feet can be obtained, a system of cleaning the sewer should be calculated in its construction and strictly adhered to. Sewers to be cleaned should never be less than two feet in diameter. circular. If more fall than eighteen inches per hundred feet is met in the line of the sewer, tumbling basins should be used as often as is necessary to reduce the fall to the maximum eighteen inches.

Regularity of fall is even a more necessary consideration than the total amount of fall. The most difficult and expensive part of the control of the sewers already constructed in our city is that resulting from irregularity of fall. The total is generally sufficient to allow best of drainage but in the construction irregularities occurred. Sections occur one hundred feet or more in length in which the fall is rapid, then a section in which the fall is scarcely or not perceptible, forming almost a basin for the accumulation of filth and materially reducing the capacity of the sewer. This sort of construction is what probably every one here to-day would emphatically denominate "poor construction." And you would be right, for so it is.

The material of construction I have found to be best for our purpose is brick. Stone is good if cut; but if laid as quarried, especially in large sewers, the liability to wash is so great as to make their use very questionable as to results. One of our main sewers 10x12 feet is built of stone for the invert and walls, and brick for the arch. There are some parts of it composed wholly of brick also. The stones are quarry faced and when the sewer is full the stones are actually forced out of their positions in the bottom and carried away. It has been necessary to reconstruct several breakages for that reason at much more than the original cost of construction. Where the sewer is constructed entirely of brick the bottom is now, after many

years, smooth and firm with no indication of giving or washing away. Cut stone has about the same smooth surface as brick and is just as acceptable. If the facing of the inside could be of cut stone, the backing of the walls to any thickness might be of common rock, faced, with same results. Or if the facing were made of brick it would be as acceptable.

The concomitants of sewers naturally are foulness and sewer gas. The foulness comes from the nature of the substances sewers are made to remove and the gas from the substances themselves. From a sanitary point of view this subject is more important than the construction except as the construction enters into the subject of the rapid removal of the refuse matters and their disposal.

The sewers should be so constructed as to give as little obstruction as possible to the rapid flow of the matters coming into them. But if the filth is removed so slowly as to become stagnant or to take more than twenty-four hours to pass through them, chemical action or decomposition takes place and pestilential vapors are formed blighting every form of life that requires the presence of pure atmospheric air.

A rapid disposal of the sewage is the way to dispose of the difficulty of foul sewers. This can be done in small cities where the systems of sewerage are not so extensive as to require more than twenty-four hours for any matter to pass through them. However, no matter how rapidly the sewage is disposed of, the material of construction becomes saturated with foul matter and small particles are left in crevices and whatever lodgment there may be, and from these detained particles noxious gases arise that are less vitiating only as they are more diluted with atmospheric air. A system of careful ventilation must be strictly followed in order that the gases arising from these sources may be made as nearly harmless as possible. My method has been to so place and construct the sewers of our city that the sewage may be disposed of in less than twenty-four hours, and then to have as thorough a system of ventilation as is practicable. This I do by having perforated manhole covers and untrapped street inlets to the sewers. The flow of water from the streets and elsewhere has a tendency to carry with it currents of air. By this mechanical means and the easy ingress of atmospheric air or vapors, the pressure of sewer gas will be entirely abated. But as a further and additional precaution, I require wherever possible the proper ventilation of the upper end of all house connections. These are done generally by pipes running to the tops of houses, into flues or in some like manner. We require a system of trapping between the sewer and upper end of all house drains and usually the ventilators just spoken of are of more consequence in protecting against the foulness of the house drains themselves than from pressure of gas from the sewer.

By following these methods as nearly as possible we have had almost uniform success in disposing of the difficulties of foul sewers

and have had no positive instance of unhealth arising from contamination from sewer gas, and the City of Springfield is to-day equal to any and far ahead of many cities of equal population as regards cleanliness and general health.

Mr. Bullard, by request, expressed his opinion upon the relative merits, first, of the circular and the egg-shaped cross section for sewers, and secondly of the combined and separate systems. He said that where a constant flow sufficiently copious to prevent the deposition of sediment to any great degree, is furnished, the circular cross-section is to be prefered both for brick and pipe sewers, on account of the considerations of economy—of construction in the case of bricks, and of cost of material in the latter case ; but where the flow is, as a rule, but slight, the egg-shaped is preferable, as it affords a greater cross-section of flow for the same extent of wetted perimeter of sewer than is possible in the circular, thus insuring a greater velocity and a consequent prevention to the serious retardation to the current by obstruction. He stated that Springfield has the combined system of sewerage and that it seems better suited to the existing circumstances, than the separate system would be. He stated that in his experience, a 2 foot brick sewer, with an average cut of about 9 feet, costs about $1.05 per foot.

Mr. G. F. Wightman expressed himself as favoring surface drainage for storm water where at all expedient, for the reason that it saves the enormous expense of constructing the large sewers necessary in the ordinary combined system ; strongly favored bricks as a material for sewer construction, for reasons both of economy and durability ; gave instances of a six foot brick sewer in Peoria which he has not seen running full even in the heaviest storms ; also mentioned a sewer through which the water from an Artesian well finds an outlet, in which the sand and gravel held in mechanical suspension in the water has in a very few years worn off five inches of hard limestone invert.

Mr. C. W. Clark.—Gave dimensions of what he claimed to be the largest sewer in the world, in course of construction in St. Louis, Missouri.

MUNICIPAL ENGINEERING.

By A. H. BELL, of Bloomington, Ill.

So diversified in its nature is the practice of a City Engineer, that to give a discourse upon such a subject in one short chapter, is much like looking for a starting point to commence the winding up of an endless chain. It will be my endeavor only to give a few ideas evolved in my own practice. *Experience* is said to be an expensive teacher, though its utility no one will question. Theory is inestimable and indispensable, but it is only by a happy combination of these two elements that we arrive at those facts and conclusions which alone are incontestable. Now as to what municipal engineering may consist of, and what may be expected of one who is in the practice of this branch of the profession. It is expected that he shall have a thorough knowledge of the construction of sewers in all their details; the construction of water works and street pavements; establishing grades for streets and sidewalks; prepare specifications for all city contracts and ordinances, and act as a supervising architect over all public improvements of whatever nature contemplated, and be responsible for their proper construction. It is further expected of him who may follow the profession of a municipal engineer, that he shall attend the periodical meetings of those elected by the people to manipulate city affairs, the "City Fathers" as they are familiarly known, and there be ready to give, impromtu, the relative capacity of sewers of all dimensions and under various rates of inclination; their cost, and the proper sizes to adopt in all instances; the cost of water mains and street pavements per lineal foot, and in fact act as a sort of a walking encyclopaedia. Having attained all these acquirements the average engineer is still unqualified for office unless his political views shall coincide with the powers that predominate.

Believing this to be sufficient for preliminary surmising I shall endeavor to give a few practical ideas acquired in the practice of the profession in the City of Bloomington, Ills. Prominent among the improvements of every city are its street pavements. Bloomington has experimented with the block pavement, both cedar and pine; the former has proven too costly and the latter too perishable for our use; though during the life of either, they make a most desirable pavement. We have tried block stone and McAdam, and still being ambitious, experimented with brick pavement which has given the most general satisfaction, as regards cost, service, and durability. We

have one block of brick pavement which has seen nine years of active service, having been repaired but once at an expense of about $30, and is still in very good condition. There is now somewhat more than a mile of this style of pavement in use in Bloomington and about an equal amount contemplated for the coming season.

The general plan of construction is to make a good solid foundation of cinders, covered with sand, thoroughly rolled and compacted, upon which we lay a course of brick upon their flat surface, the longest dimension being parallel with the street, breaking joints with the brick in all cases ; over this is spread a layer of sand about an inch in depth, when the top course of brick is laid on their edges or two inch surface across the street. A top dressing of one inch of sand is then spread over the entire work and the same is thoroughly brushed and rolled so as to effectually fill all crevices. Where a good quality of brick can be had, this makes a very desirable and economical pavement. It is comparatively noiseless, pleasant to drive over, durable, and easily repaired. Its cost with us has been from $1.50 to $1.65 per square yard.

We are now using brick for sidewalks in the residence portion of the city, also for street crossings where no pavements exist, as they are more durable and a more easy and natural approach to them can be attained than was the case with the ordinary plank crossing. It is a cheaper crossing than stone in our locality. Of stone curbing we set last year about three quarters of a mile, Joliet lime stone, twenty-four inches deep by four inches thick, at the cost of 62 cents. per lineal foot. The city has just contracted for the setting of 5,416 feet of curb stone during the coming season at 58 cents per lineal foot, including all material and labor, circular corners, 5 feet radius, to be measured the same as square corners. The stone used in this contract will be the McDermott and Berea sand stone of Ohio.

Bloomington has now about completed its system of main sewers. We have them constructed of brick from 2 to 8 feet diameter in the clear, all circular in form. Nothing larger than three feet diameter are built with a single ring of brick, two courses of brick being used for sewers of 4 to 8 feet diameter. All sewer work has been done by contract. Composition of mortar required has generally been two parts of sand to one of cement, mixed dry and then sufficient water being used to give the proper consistency, always taking into consideration the condition of the brick and the trenches.

My method of setting grade stakes in the construction of sewers is briefly as follows: It might not be practical in cities where extremely light grades only are attainable. The minimum grade I have had to contend with in city practice has been three inches to one hundred feet. Having made a preliminary survey along the proposed route for the construction of a sewer, noting various bench marks along the line, and making such measurements as are necessary for a map of location, the proper dimensions being determined, a profile of the surface elevation is made along the entire line, upon which the

grade line is fixed and established. When the work of construction is ready to commence, stakes are set, generally fifty feet apart, and six inches from the proposed line of the trench, being carefully numbered in succession, station or stake No. 0 being at the point of commencement or outlet of the sewer. These stakes are left to project about two inches above the surface of the ground, and others are driven to the surface along the sides of each of the first set of stakes adjacent to proposed trench for the sewer. Continuous levels are then run, taking rods on the tops of the latter stakes and noting carefully the corresponding number of each station. From these elevations and the established grade line the curbs are readily determined. By the use of a straight edge and a small pocket level, stakes may be set in the sides of the trench, and a string stretched from one to the other will give the required grade for setting centers at any point.

The location of all junctions for laterals and private drains are noted from the stakes that are numbered. Having under construction five different sewers at one time during the past season, the above method proved a very satisfactory and economical procedure. It is my preference to use a self-reading rod almost exclusively in the practice of levelling, having one of my own make, graduated to 100ths of a foot, upon which a target can be used with a vernier attachment where greater precision is desired.

All sewers and other public improvements in the City of Bloomington are constructed under the special assessment system, adjacent property owners paying about one-third of the estimated cost and the city at large the balance. As a permanent record for all sewers built in the city, two plats are recorded for each, one being a special assessment plat, showing the location of the sewer and the amount of assessment on each lot, and the other a profile, giving surface and grade elevations, the location of all junctions, stations, the cuts, &c.

Of vitrified sewer pipe we lay a considerable amount every year. We have used of late years the Blackmer and Post manufacture, of St. Louis, which is well vitrified, evenly burned, and has given very general satisfaction. For private drains my preference is the Y Junction used in connection with the $\frac{1}{8}$th curve.

A few words as to the ventilation of our sewers. In Bloomington we are favored with a very good gradient in the majority of cases, so that, though we have no flushing apparatus, our sewers become well flushed at times of high water. There is, however, a great portion of the year when not sufficient current is maintained to keep them self-cleansing. We are beginning more every year to feel the necessity of a system of ventilation more effective than our present ventilating manholes located along their lines. It is my opinion that the construction of a few ventilating chimneys or escapement shafts will tend largely to obviate the trouble and I shall so recommend in the future. We have in use a few of the "Clapp Sanitary Trap," manufactured by R. P. Jackman & Son, of Elgin, Illinois, which are effective in confining the atmosphere of the sewer, but to adopt them

universally without sufficient escapement shafts would certainly be injudicious. We think the most effective and simple disposition of sewer gas, where at all practicable, is to get as much exterior air into the sewer as possible, and relieve it of its own gaseous element, thus diffusing and diluting it to such an extent that it may become harmless. I might say in conclusion that the questions which are submitted to the municipal engineer in his every day practice, are such as require as much good sound judgment from experience and observation as professional or technical skill. He who would be successful in this capacity must be practical and not depend upon trigonometrical functions for the solution of all problems.

Mr. Bullard favored brick pavements as being proportionally more durable, and far more preferable from a sanitary point of view, than cedar block pavements. He gave cost of pavements in Springfield as follows: Cedar block pavement—per square yard $1.38½.

Mr. Wightman as in the case of sewers, argued in favor of brick for pavements ; gave cost as follows: Cedar block pavement, per square yard, $1.38; brick pavements, per square yard, $1.55.

THE SUBDIVISION OF FRACTIONAL QUARTER SECTIONS.

WHAT IS A "HALF-QUARTER SECTION, VIZ., 80 ACRES," AS APPLIED TO FRACTIONAL QUARTER SECTIONS?

By Z. A. ENOS, of Springfield.

The legal mode of subdividing the quarter sections on the north and west sides of the townships into halves, or lots one and two, in all cases where the plats by which the lands were sold do not designate the manner in which it is to be done, is another subject of much controversy among surveyors. I think it is now universally admitted, that where the Surveyor General has indicated by the distances marked on the plats which he furnished the land office how the subdivisions were to be made, and the lands were sold by those plats, then the survey must conform to the mode indicated. But the number of cases so shown are less than one-half of the whole, and of this number there appears to have been no fixed or clearly defined rule governing the mode of subdivision. One portion of the plats will show double corners on the section and half section lines for the half-quarter sections, or lots one and two; other plats will show that a common corner for both sides of the section and half section lines are to be made; still other plats will show only a part of the quarter sections on the plats to be divided by one or the other of the above modes, and the remainder of the quarter sections without anything to designate the manner of their division. Again, some of the plats will have both double and single corners indicated, while a large majority of all the plats are without any mark or showing of the lengths of the lines for the half-quarters or lots, and in nearly all cases where lines are drawn on the plat marking a division of the quarter sections into halves, or lots one and two, the areas of the tracts are marked the same on the plats, whether the division is by one mode or the other—the one-half, or lot one, containing 80 acres, and the remaining fractional half, or lot two, containing the residue of the whole area of the fractional quarter section.

Now it is very evident that the two modes of division will produce entirely different results, not only in the length of the lines and placing the corners, but in the actual contents of the half-quarter sections or lots.

The double-corner plan divides the fractional quarter section according to area, making the corner for the half-quarter section, or lot one (on the U. S. measured fractional quarter section line) at a distance as much more or less than 20 chains from the quarter-sec-

tion corner as may be requisite to cut off exactly 80 acres for the half-quarter section, or lot one, and the remaining amount of the acres (stated for contents of the whole fractional quarter section) in the fractional half-quarter, or lot two, and thereby making a separate corner for these divisions on each side of the section and half-section lines.

The other, or single-corner plan, divides the fractional quarter section according to the measured length of lines as shown by the plats, giving to the half-quarter section, or lot one, 20 chains of the stated distance, and to the fractional half-quarter section, or lot two, the remainder of that distance, without regard to the contents of the division thus made.

The first plan makes double corners on every fractional section line closing on the township and range boundaries. The second plan makes a single corner common to both sides of these lines, the same as the corners for the half sections and quarter sections were made by the government surveys.

Prior to 1842, none of the plats in the Surveyor General's office for Illinois show any marked distances for the widths of the half-quarter or lot subdivisions of the fractional quarter sections on the north and west sides of the townships. In 1842 and 1843, the calculations for cutting off of exactly 80 acres for the half-quarter section, or lot one, from the south and east sides of the fractional quarter sections were, in many instances, made in the Surveyor General's office, and the distances marked on the plats, thus indicating the double corners on these lines. In 1844 this mode of division appears to have been abandoned, and the common mode of division by line adopted, and ever since that date, whenever the distances are indicated on the plats as furnished by the Surveyor General, the widths of the south and east half-quarter sections, or lots one, are marked as 20 chains, thus making the single or common corner for both sides of the fractional section and half-section lines. In some instances the plats that were originally marked according to the plan of 1842 have been changed to conform to the plan of 1844, and in the land office books and the patents the divisions are usually described in the north tier of quarter sections as the south-half of the quarter section, containing 80 acres, and the north half, north fractional half, or north part of the quarter section, containing the remaining contents of the quarter section, whatever it may be. At other times, they are described as lot one or part one of the quarter section, containing 80 acres, and lot two or part two of the quarter section, the remaining area. Then again, one part of the fractional quarter section will be described as a half and the other as a lot. The same is true of the west tier of quarter sections, except that they are designated as east and west halves, &c.

The question that is suggested by the foregoing facts is, which is the legal mode of division in those cases where no plan of division is shown on the plats?

Before entering into the discussion of the question, it would be well first to carefully consider the law of congress on the subject, and the rules and regulations of the Secretary of the Treasury issued in pursuance thereof. The act of congress which authorized the subdivision into, and the sale of, half-quarter sections was the act of April 24th, 1820, and provided that "In every case of the division of a quarter section, the line for the division thereof shall run north and south, and the corners and contents of half-quarter sections which may thereafter be sold *shall be ascertained* in the *manner* and on the *principles directed* and *prescribed* by the *second section* of an act entitled 'An act concerning the mode of surveying the public lands of the United States,' passed on the 11th day of February, 1805; and *fractional sections*, *containing 160 acres or upwards*, SHALL IN LIKE MANNER, *as nearly as practicable*, *be subdivided into half-quarter sections*, UNDER *such rules and regulations as may be prescribed by the Secretary of the Treasury;* but fractional sections containing less than 160 acres shall not be divided but shall be sold entire." The Secretary of the Treasury, by virtue of the power thus conferred, on the 10th of June, 1820, issued a circular to the Surveyors General, directing that "fractional sections containing more than 160 acres should be divided into half-quarter sections by north and south or east and west lines so as to preserve the most compact and convenient forms." On the 15th day of June, 1821, the Secretary sent a similar circular to the Registers of the Land Office, directing them "to mark the division on the plats, inasmuch as it would be impracticable for the Surveyors General to report them in time for the land sales." These circulars, from their very general and indefinite nature, were intended to apply to those irregular fractional sections formed by rivers, water courses, and other similar boundaries, for which it was impossible to lay down any precise rules or place other restrictions upon the discretion of the officers, than that the half-quarter section should be compact, and the lines north and south or east and west; and though differently construed and acted upon by many of the officers, yet that such was the Secretary's intention, he has stated in the particular rules and regulations for the division of the fractional sections on the north and west sides of the township that were afterwards issued by him, as follows:

"CIRCULAR TO SURVEYORS GENERAL.

"NOVEMBER 9, 1821.

"SIR:—By the first section of the Act of April 24, 1820, all the public lands of the United States shall be offered at public sale in half-quarter sections; and fractional sections containing one hundred and sixty acres and upwards shall, as nearly as practicable, be divided into half-quarter sections, under such rules and regulations as may be prescribed by the Secretary of the Treasury; but fractional sections containing less than one hundred and sixty acres shall not be divided, etc. By the Act of May 10; 1800, section 3, the excess or deficiency of regular sections or quarter sections in any township is to be thrown on the north and west sides of the township, making fractional sections more or less than one hundred and sixty acres. In subdividing such fractional sections to form a half-

quarter section, viz., 80 acres, the Secretary of the Treasury directs that the subdividing line for such fractions as lie on the north side of a township shall be an east and west line, forming the half-quarter section on the south side of the fraction ; and for such fractions as lie on the west side, the subdividing line shall be a meridian, forming the half-quarter section on the east side of the fraction. This mode of subdivision will preserve the compactness of the tracts with the general divisions, and will not interfere with the rule adopted relative to fractions formed by a stream, a river, etc."

To Surveyor General Rector the following :

"This mode of subdividing is precisely the one adopted by yourself, but as it has not heretofore been generally adopted, the object of this circular, you will perceive, is to approve your plan, and make it a general one."

The Act of 1820 having made the 2d section of the Act of 1805 the governing principle for the subdivision of the quarter section into half-quarters, is here given in full. It is as follows :

SEC. 2. *And be it further enacted*, That the boundaries and contents of the several sections, half sections and quarter sections of the public lands of the United States, shall be ascertained in conformity with the following principles, any act or acts to the contrary notwithstanding :

1. All the corners marked in the surveys, returned by the Surveyor General, or by the surveyor of the land south of the State of Tennessee respectively, shall be established as the proper corners of sections or subdivisions of sections, which they were intended to designate ; and the corners of half and quarter sections, not marked on the surveys, shall be placed, as nearly as possible, equidistant from those two corners which stand on the same line.

2. The boundary lines actually run and marked in the surveys returned by the Surveyor General, or by the surveyor of the land south of the State of Tennessee, respectively, shall be established as the proper boundary lines of the sections or subdivisions for which they were intended ; and the lengths of such lines, as returned by either of the surveyors aforesaid, shall be held and considered as the true length thereof. And the boundary lines which shall not have been actually run and marked as aforesaid, shall be ascertained by running straight lines from the established corners to the opposite corresponding corners ; but in those portions of the fractional townships, when no such opposite corresponding corners have been or can be fixed, the boundary lines shall be ascertained by running from the established corners due north and south or east and west lines, as the case may be, to the watercourse, Indian boundary line, or other external boundary of such fractional township.

3. Each section or subdivision of section, the contents whereof shall have been, or, by virtue of the first section of this act, shall be returned by the Surveyor General, or by the surveyor of the public lands south of the State of Tennessee,respectively, shall be held and considered as containing the exact quantity expressed in such return or returns ; and the half sections and quarter sections, the contents whereof shall not have been thus returned, shall be held and considered as containing the one-half or the one-fourth part, respectively, of the returned contents of the section of which they make part.

The arguments advanced to sustain the first position are, that contents are the important consideration—the gist and governing principle in the division—that fixes the dimensions and corners of the tracts, and that by the expression "a half-quarter section, viz., 80 acres," as used by the Secretary's circular, the words a half-quarter section are but an expression applied to the division designed to fix its location in the quarter-section, not having their literal meaning and usual legal controlling force in the division of the fractional

quarter-section either by bisecting its lines or halving its area, but are qualified and entirely controlled by the expression accompanying contents "viz., 80 acres," and are to be construed as meaning no more or equivalent to the words lot one ; that the act of 1800 required that the fractional sections and half sections bounded on the northern and western lines of the township should be sold as containing only the quantity expressed in the returns and plats, and all others as containing the complete legal quantity ; that this act itself, as well as the rules and regulations of the Secretary, have made a distinction in the character of the contents of fractional and full sections, the 1st being certain, definite and governing—the 2d uncertain, indefinite in fact, and without any controlling power, and as the contents of these fractional quarter-sections as returned were actually computed in the Office of the Surveyor General by certain well known and established rules of calculation, that it would follow as a necessary implication that the same rules of calculation should govern the computation of the contents of the halves or lots that were applied to the whole fractional quarters, and the areas of these half-quarters being computed in the same manner that the fractional quarters were calculated, it consequently follows that their widths will vary with the ever varying dimensions of the different fractional quarters, and with that difference in width a corresponding variance in the corners, thus resulting in the making of double corners for these half-quarter sections on every section and half-section line ; and that this construction of the law of contents was early established, is evident from the communication of the commissioners of the General Land Office to the Register at Palestine, Ill., of date June 10th, 1825, in which he uses the following language: "The large excesses which are thrown on the north and west sides of the township are necessarily subdivided into lots of 80 acres, as near as may be, which are designated numerically." And further, that such a mode of division is an equitable division of the whole contents of the fractional quarter section between the purchasers in the proportion that each purchased, and the only mode that will do exact and perfect justice to all parties in interest.

On the other hand, the advocates of the common corner contend that the half-quarter section alluded to by the Secretary of the Treasury is a tract of land of certain fixed and uniform dimensions, being the half, or equivalent to a half, of a full or regular quarter section, the two divided sides of which quarter section are each 40 chains in length and its legally declared contents 160 acres ; and that the attached "viz., 80 acres," was merely used to designate this intended half-quarter section, from an actual half of the fractional quarter section. And they argue that the law requiring that "fractional sections, containing 160 acres or upwards, should as nearly as practicable be subdivided into half-quarter sections," would without these qualifying words of the Secretary's rules and regulations have demanded absolutely an equal division of their lines ; which would have

resulted in the making subdivisions of the fractional quarter sections out of character with and disproportionate to the general divisions of the half-quarter section, in many instances making the half of the fractional quarter greater than a regular quarter section, and that it was to preserve and maintain such uniformity of division, and not to create a new kind or character of division, governed or restricted by exact area, that the Secretary attached to the descriptive words "a half-quarter section," the explanatory words "viz., 80 acres," which quantity is merely the legally declared contents of every regular half-quarter section ; and that therefore the dimensions of this half of the fractional quarter section should be similar and correspond with the dimensions of the regular quarter sections ; and as the regular quarter sections are 40 chains north and south, and corners common to both sides, so this half of the fractional quarter should be the half of 40 chains and its width be 20 chains and corners common to both sides of the section or half section line.

The foregoing is a brief statement of the positions assumed by the advocates of the two different modes of division. Believing the last to be the correct position, I will now proceed to give my reasons for it. As the whole question turns upon the proper construction to be given to the Secretary's rules and regulations, in order to get a clear comprehension of their purport, it will be necessary to have at least a general knowledge of the manner in which the townships were subdivided into sections, half sections and quarter sections.

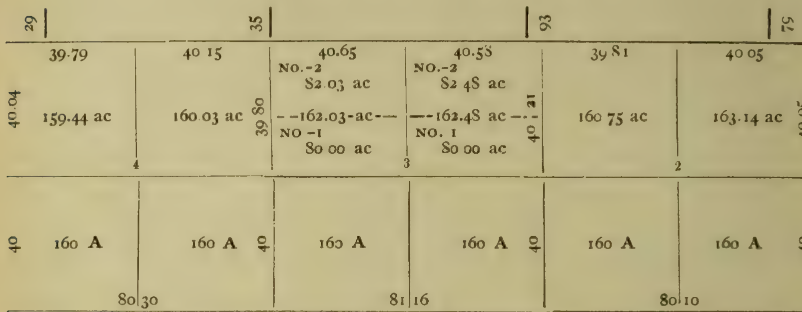
They were usually subdivided upon the plan of running meridian lines (or assumed meridian lines) from the established section corners on the south boundary of the township north to the intersection of the northern boundary, and establishing quarter section and section corners at each half mile and mile (or 40 and 80 chains) exact measurement of line so run, and then connecting these section corners thus made by east and west lines, establishing the half section corners thereon equidistant between these section corners, whatever the distance might be between them whether more or less than 80 chains, they in fact seldom measuring that distance according to the government chaining as is shown by the returned notes and plats. This was the manner of survey for all the sections except the north and south boundary lines of the west tier of sections, which were made by running west to the intersection of the range line and establishing the half section corners at 40 chains west from their east section corners. These sections and subdivisions of sections into halves and quarters thus made, and whose east and west sides or boundary lines are exactly 40 and 80 chains measured distance, are denominated full or regular sections, half sections and quarter sections, containing in law exactly 640, 320 and 160 acres, respectively. And in nearly all the full or perfect townships which contain the prescribed 36 sections, there are 25 full and 11 fractional sections, 55 full half sections, 17 fractional half sections, and 121 full quarter sections and 23 fractional

quarter sections. Now of all these full quarter sections being in length north and south precisely a half a mile or 40 chains government measure, and containing in law exactly 160 acres, if they were divided by east and west lines in the manner as provided in the Secretary's rules and regulations, their halves would be each the half of 40 chains in width, and their legal contents exactly 80 acres each, and in the words of the Secretary, each would be "a half-quarter section, viz., 80 acres." And the converse of this must be equally true—that if you cut off by an east and west line a half-quarter section, viz.: 80 acres, from one of these full quarter sections, the subdivisions so made would be the half of the quarter section, and its north and south width would be 20 chains. And as by the act of 1820 the full quarter sections were to be subdivided according to the provisions of the act of 1805, so these fractional quarter sections were to be in like manner as near as practicable subdivided into half-quarter sections under such rules and regulations as may be prescribed by the Secretary of the Treasury, which rules and regulatious direct that the subdividing line for such fractions as lie on the north side of the township shall be an east and west line, forming the half-quarter on the south side of the fraction ; and for such fractions as lie on the west side, the subdividing line shall be a meridian forming the half-quarter section on the east side of the fraction, thus showing an evident intention that this half-quarter section should be cut off in conformity with and similar to the division by an east and west line of a full quarter section, and consequently make the half-quarter sections, or lot one, 20 chains wide, government measure. This is the only division of the fractional quarter section that can be made that will fill both requirements—"a half-quarter section and 80 acres."

This line of reasoning, deduced from the general principles of subdivision, becomes still stronger, if not conclusive, when considered with reference to the manner of subdividing the fractional sections into halves and quarters. They are divided into halves in the west tier of fractional sections by lines running north and south at exactly 40 chains distance from the northeast and southeast corners of the sections, and in the north tier of fractional sections into quarter sections by lines running east and west at the distance of 40 chains from the southeast and southwest corners of the sections, thus cutting from the fractional sections what are called full or regular halves and quarter sections on the east and south sides of these lines, and fractional halves and quarters on the west and north sides. Or in other words, it is the taking from the whole fractional sections (and bear in mind by the acts of 1800 and 1820 the whole section is regarded as a fraction) exactly 40 chains of the measured length of their lines (the lines in which the excess or deficiency of measurement was thrown according to the provisions of the act of 1800), and establishing the half and quarter section corners at that distance, without any regard to the remaining length of lines, or the actual contents cut off. Thus, take for illustration any fractional section

on the township or range line—say section 3, township 17 north, range 8 west 3d p. m., as shown by the accompanying plat:

T. 17 N., R. 8 W., 3d P. M.



Its boundary lines are on the east 80.21 chains, on the west 79.80 chains, on the south 81.16 chains, and on the north 81.23 chains. The quarter section corners on the east and west are at exactly 40 chains from the S. E. and S. W. corners of the section, and common to the sections on both sides. And the straight line connecting them cuts off from the whole fractional section, (which was to be sold as containing only the quantity expressed in the returns and plats), the S. E. and S. W. quarters, each returned as containing 160 acres, but in fact containing over 162 acres each, as is manifest from the returned measured widths of the section. Now the correctness of this subdivision cannot be questioned, for the government made the corners and the law declares them to be the proper corners, and 160 acres as the exact area of each quarter section. Nor would their further subdivision into half-quarters and quarter-quarters by the bisecting of their boundary lines, with the resulting declared legal contents of 80 and 40 acres respectively, be controverted. Then what reasonable objection can be urged against the subdivision of the remainder of the fractional section in the same way, the cutting off in the same manner from the south sides of the N. E. and N. W. fractional quarters, of regular half-quarter sections. Both analogy and general principle would seem to sustain it.

There never has been claimed but three modes for their subdivision. 1st, by an equal division of their lines, or areas (which is not now insisted on); 2d, by making the half-quarter section exactly 80 acres; and 3d, by making the half-quarter in the same manner and on the same principles that the S. E. and S. W. quarters were made. The last under the restrictions of the Secretary's rules and regulations, would be as near a conformity as is practicable to the provisions and principles of the acts of 1805 and 1820 (nearer than the cutting off of exact 80 acres) and certainly as strict a compliance with the requirements of the law as was the cutting off from the whole fractional section of the S. E. and S. W. full quarter sections, the cor-

rectness of which no one disputes. And remembering that by the acts of 1800 and 1820 the whole section is fractional, then evidently a subdivision of these fractional quarters in this manner is as much the cutting off of the half-quarter section, viz., 80 acres, as was the subdivision of the whole fractional section in the manner in which it was made—the cutting off of the quarter sections, viz., 160 acres. And that they are quarter sections, viz., 160 acres, we cannot deny. This is but the application to the fractional quarter sections of the same rules and principles of subdivision which under the act of 1800 has always been applied to the division of the fractional sections into halves and quarters. Then, with these principles and practice with regard to the subdivision of the fractional sections into full and fractional half and quarter sections in practical operation and general recognition for more than twenty years prior to the date of the Secretary's rules and regulations, can there be any reasonable doubt that he intended by those rules and regulations to adopt and apply the same principle to the remaining fractional quarter sections that had been applied to the whole fractional sections—to merely formulate this practice and principles in regard to the fractional sections into rules and regulations for the subdivision of the fractional quarter sections, which otherwise, under the provisions of the act of 1820, would all have had to have been divided by north and south lines into equal halves.

Then again, we should not lose sight of the fact that area is not the controlling principle in the U. S. land system of subdivision, and that the mile and its equal division of halves and quarters is; that the common-law principle that the call of a patent or deed for a half, a quarter, or quarter-quarter of a tract of land, is to be construed as that exact portion of the whole contents or area of the tract, regardless of any equality in the boundary lines of the parts, has been totally reversed in the public land system. By the various acts of congress in relation to the survey and sale of the public lands, such a call would require an equal division of the two or four opposite boundaries of the tract, by a straight subdividing line or lines, without any regard to the actual equality in the areas of the parts, the law declaring the subdivision made in that manner to be equal in contents, as may be seen by reference to the acts of May 18, 1796, May 10, 1800, February 11, 1805, April 24, 1820, and April 5, 1832. The first four were in force at the date of the Secretary's rules and regulations. And in no instance are the full or regular sections, or the fractional sections (made fractional by the excess or deficiency in the lengths of the closing lines on the township or range boundaries), or the regular half and quarter sections, as returned by the Surveyor General, the actual and true contents of the several tracts, nor are they in fact equal. Yet by virtue of the laws of congress, their returned contents are to be taken as true, and when the returned contents are stated in amounts the same, are to be con-

sidered equal. And even though the claim for computed contents was tenable under the act of 1800, which says that "such [fractional] sections and half sections shall be sold as containing only the quantity expressed in the returns and plats respectively, and all others as containing the complete legal quantity," yet the subsequent act of 1805 has declared that "each section or subdivision of section, the contents whereof shall have been or shall be returned by the Surveyor General, shall be held and considered as containing the exact quantity expressed in such returns;" and as all have been so returned, wherein can one returned contents have more virtue or legal importance than another? They are all in law to be held and considered as exact, and can the computed contents be more than exact? Even though as a matter of fact the computed contents are more nearly accurate, still their legal status is the same.

A careful examination of the above cited acts should satisfy any one that the legal distinction between what are termed in law mandatory and directory provisions has been clearly made by these acts in favor of distance as against contents, making the mile and its equal divisions mandatory, while contents, to say the most for it, is but directory. Thus the act of 1796, after providing that the township should be six miles square, says they "shall be subdivided into sections containing as nearly as may be 640 acres, by running through the same each way parallel lines at the end of every two miles, and by marking a corner on each of said lines at the end of every mile," and the act of 1800 provided for the quarter townships "to be subdivided into half sections of 320 acres each, as nearly as may be, by running parallel lines through the same from east to west and from south to north at the distance of one mile from each other, and marking corners at the distance of each half mile on the lines running from east to west, and at the distance of each mile on those running from south to north." Here it is evident that the mile and half mile distances are mandatory, *that must be*, and the contents are merely approximations, and at the best but directory.

In the same sense did the Commissioner of the General Land Office, in his communication to the Register at Palestine, Ill., use the words "80 acres as near as may be." The expression and its application being almost identical with the words of these acts, it is evident he intended to convey the same meaning, from his using the language of the statutes to express his ideas, and thereby meaning nothing more than such an 80 acres as the government system of the subdivision of fractional sections into halves and quarters would make. It would be a strained construction of the Secretary's rules and regulations that would make area the governing principle of subdivision, when the acts of 1805 and 1820, and all previous acts, had made the equal division of the mile the rule for such subdivisions, and area but the legally declared consequence of those divisions. Such a construction, instead of conforming as nearly as practicable (in the subdivision of these fractional sections) to the provisions of

the act of 1820 and the principles of the act of 1805 as was required by the act of 1820, would be a total disregard and reversal of all their provisions and principles.

The subordinate character of area as regarded by the Land Department is clearly set forth in the following extract from a communication of Albert Gallatin, Secretary of the Treasury, to the surveyor of the lands &c., Washington, Mississippi Territory, of date March 13th, 1805, enclosing act of 1805: "You will also perceive, from the enclosed act, that the principal object which congress have in view is that the corners and boundaries of the sections and subdivisions of sections should be definitively fixed, and that the ascertainment of the precise contents of each is not considered as equally important. Indeed, it is not so material, either for the United States or for the individuals, that purchasers should actually hold a few acres more or less than their surveys may call for, as it is that they should know with precision, and so as to avoid any litigation, what are the certain boundaries of their tracts."

And as regards the claim of superior equity that is made for the double-corner system, or subdivision by exact area, the answer to it is short—that the land system of the U. S. is not governed by the rules of equity, but the fixed principles and rules of law; and although the mode of subdivision by the single corner may not divide the areas of the fractional quarter sections in the exact proportions in which they were sold, the same is also true of all the other government subdivisions; and if equity can control one, it can all, and thus change the whole land system.

But the conclusive argument for the single-corner plan of subdivision is to be found in the construction given to the Secretary's rules and regulations by the Land Department of the government, as shown by the plats and sales (with the two years' exception before stated), and also from the instructions it has issued to the U. S. Deputy Surveyors and Surveyors General. The first, from the Surveyor General's office for Illinois and Missouri to U. S. Deputies, is as follows: "When the closing lines to the north or west boundaries of the township, either in subdivision or exterior work, exceeds 100 chains in length, corners for the *legal subdivisions* of the sections will be established at *20 chains* north or west of the quarter-section corners." Here is the distinct declaration that the legal subdivision of the fractional quarter-section is 20 chains. The second is contained in the Manual of Instruction to Surveyors General, by the Commissioner of the General Land Office, in these words: "The lots in the extreme northern and western tiers of quarter sections, containing more or less than the regular quantity, are always to be numbered as per example. Interior lots in such extreme tiers are to be *twenty chains* wide, and the excess or deficiency of measurement is always to be thrown on the exterior lots : elsewhere the assumed subdivisional corner will always be a point equi-distant from the established corners." And of this departmental

construction of its own rules and regulations, Attorney General Butler has said, in an opinion given to the Secretary of the Treasury: "The department is perfectly competent and best qualified to construe its own instructions." And further, this Manual of Instruction having been approved and adopted by act of Congress in 1862, its rulings and construction may be considered as having the weight of legislative sanction and construction.

And now in conclusion, and by way of recapitulation, for the reasons before stated, I believe that; 1st, the double-corner plan is at war with the whole government system of survey in this, that it makes area the governing principle of subdivision instead of the mile and its equal parts of half and quarter miles. 2d, that instead of conforming as near as practicable to the manner and principles provided for subdivision in the acts of 1805 and 1820, it antagonizes every principle therein contained. 3d, that it would make two conflicting rules of subdivision for every fractional section, one portion by equal divisions of the mile regardless of actual area, the other portion by actual area disregarding the equal divisions of the mile. 4th, that the method of division by the quarter mile is the nearest conformity to the provisions of the acts of 1805 and 1820, and is in perfect accord with the general system of subdivision. 5th, that the division by the quarter mile strictly conforms with the manner and principles of the subdivision of the fractional sections into halves and quarters, which has ever been pursued and was in general use at the time of, and for more than 20 years before, the date of the Secretary's rules and regulations, and therefore it is reasonable to suppose that he intended to apply the same rules of subdivision to the fractional quarter sections. 6th, that the land department, from its general practice, and specific instructions to deputy surveyors as before cited, has evidently so construed the Secretary's rules and regulations. And 7th, according to the opinion of the Attorney General, the department is perfectly competent and best qualified to construe its own instructions.

For these reasons, I believe the plan of a single or common corner the correct one.

DRAINAGE DISTRICTS—AND THE CONSTRUCTION OF DRAINAGE CANALS.

By A. H. BELL, of Bloomington.

As a country develops, so its resources come into demand. But recently the low and wet lands of this state were of little instrinsic value for agricultural purposes, their redemption being considered too expensive to be available, even if practicable. The enactment of the drainage law whereby large districts of territory may act in conjunction is bringing about a different feeling in this matter. Action under a new enactment is like venturing upon new ice, it is regarded as rather precarious, and no one likes to be the first to test it ; and in fact the old drainage law before its amendment in 1885, was more of a conundrum than otherwise, requiring a Philadelphia lawyer with eye-glasses and globe-sight attached to interpret it. Experience has developed new ideas, and from its chaotic state the law governing drainage districts has become quite tangible, though still in its infancy. The pioneer district of this state so far as I am informed is the Easterbrook district of McLean county. Being somewhat weakly in its administration under the old law, it was pretty nearly stifled under the litigation of a single individual. Since the results of work in other districts have become known, this organization has again taken life and is now in a fair way to accomplish something. It is decided to dig their ditches with dredge boats. There is about eight miles of ditches to be excavated. It is estimated this work will cost the land owners abont $3 per acre. Ditches are to be, generally speaking, 20 feet top width and 6 feet bottom width, averaging in depth 7 feet as nearly as may be practicable. It is expected this work will be executed the coming summer. Bonds will be issued payable in from 6 to 10 years. The negotiation of drainage bonds has been somewhat of a detriment to the progress of this system of improvement, not from any question of their validity, but from the fact of their being a new bond and one with which capitalists were not familiar. This class of bonds however is becoming better known and is destined to become a prominent feature in the market—when the proceedings of the commissioners are regular and in conformity with the drainage act there can be no better security.

The most extensive drainage district of this state that I know of is that of Mason and Tazewell counties, embracing about 50,000 acres of land. The work was contracted in 1884 to W. A. McGillis & Co., at 15 cents per cubic yard. They at once put in three dredges manu-

factured at Bucyrus, Ohio, and have continued to work them ever since, with little intermission. Two others have since been added of a smaller type and somewhat different style, but I think are not so successful in their operations. This firm has tried the same machine placed on wheels, to work on the banks, without success at last accounts. I know of no dredge or other machine for ditching purposes that will give sufficient lepth excepting those operating on boats. The general method of operating is to work down the stream, though it is possible to work either way by the use of dams, provided the fall be not too great.

Most of the ditches of Mason and Tazewell district are from 8 to 10 feet deep having a fall or grade of from 2 to 3 feet per mile. The main ditch which is now nearly completed is 15 miles long, running from 35 to 60 ft. top width, with a slope of 1 to 1 for the sides. There are 5 principal laterals to this main ditch, averaging 30 ft. on top and from 8 to 10 feet deep. I have not visited this district for some time, but I believe this entire contract is now very near completion. The entire work has cost somewhat over $300,000. Assessments on land will range from $2.50 to $10 an acre. The most sanguine hopes of the property owners have been realized in the results achieved by this undertaking. A district which heretofore was a paradise for the wild goose and the curlew and where the eccentric heron poised upon a solitary pedestal to watch the frolic of the frogs, is brought into the market and ranks with the best land the state can produce for agricultural pursuits. I am informed another very large district is now organized south of the Mason and Tazewell district and will furnish a large amount of work for dredge boat excavation. The Lake Fork special drainage district of Piatt county is cutting a ditch about 14 miles long, 35 feet top width and from 7 to 9 feet deep. This contract is being executed by Pollard, Goff & Co., with headquarters at Bement. They now have about 7 miles of the ditch completed. The benefits already derified are very perceptible and the land owners are much elated over the prospective results. The dredge used is of the same design as that in the Mason and Tazewell District. 1,200 cubic yards a day of 24 hours is about an average day's work for one of these machines. It requires 5 men to each day and night shift, besides sufficient help to cook and manage the cabin boat which follows in the rear of the dredge. The depth that can be obtained and the rapidity with which work can be executed, are the strong features commending the use of dredge boats for ditching purposes. Experience in this branch of the profession will soon convince the most skeptical engineer that depth is the great desideration to be obtained for an open ditch, where any considerable amount of sub-drainage is desired. While an open ditch of a very few feet depth may relieve a district of over flow at times, it will never furnish under-ground drainage sufficient for any practical use. It is not so much the water that lies upon the surface of land that renders it unavailable, but the humidity of the soil itself. The effect

of a deep ditch is similar to that of tile, to give constant sub-drainage, thereby rendering land porous and susceptible of a great degree of absorption.

The value of swamps or low land that has been properly drained, has been clearly demonstrated in many instances in this state. The North Quiver swamp, of Mason county, is the most striking demonstration of this kind to my knowledge. This tract of swamp land, about 5 miles in length and from 2 to 3 miles in width, ranged north east and south west and was one of the most impregnable swamps I have yet had to contend with in my experience of drainage engineering. It was mostly grown up with bulrushes and other rank vegetation, the water being in many instances 3 and 4 feet deep; fish abounded in numbers. I have myself seen pickerel taken out of the swamp measuring 26 inches in length; ducks reared their young and muskrats and mink reigned supreme. For the space of a mile along the middle of this swamp there was no perceptable current; from either end of the mile the water flowed but slowly, northeast into the Mackinaw in the one instance, and southwest to the Illinois river in the other, thus making a divide in the grade which was adhered to in the final construction of a ditch, that most effectually drained every portion of the swamp. The muskrats, like the Chinee, had to go. The ditch here constructed was 30 feet top width and 15 feet bottom, ranging from 7 to 9 feet deep. This land is now all available to the banks of the ditch, and I have seen growing upon it some of the best corn the state has ever produced.

DISCUSSION.

Prof. Morrow—What is the minimum size of ditches which may be profitably cut with a steam dredge?

Mr. Bell—The Mason county ditch is made by a dredge which cuts from 16 to 18 feet wide.

President Baker—How long should they be to prove profitable to the contractor?

Mr. Bell—Eight or nine miles.

Mr. Rogers, Contractor Piatt County Ditch—We cannot set up and work on jobs amounting to less than 200,000 cubic yards. We ought to have about 15 cents per yard on 5 foot depth. Can work our machine about twenty days in each month. Large ditches are constantly growing out of the failure of small ones which have been tried. I am using the Thompson steam dredge made at Bucyrus, Ohio. This company expended $20,000 in experimenting before a machine was produced that succeeded. We can give a slope of one to one to the banks. In the Piatt county ditch we have six miles of willows on the course of our ditch, some of the trees being six

inches in diameter. We have the power to pull them, but cannot get them off the bucket. The smaller the ditch, the nearer the earth is left to the edge of the ditch. We can deposit earth from 8 to 30 feet from the bank of ditch.

Mr. Stanford—What fall has the ditch?

Mr. Bell—One foot per mile.

SUBDIVISION OF ANOMALOUS SECTIONS.

By WARREN R. ROBERTS, of Sadorus.

Requests have been recently made to have a paper read before this convention on the subdivision of fractional sections. In compliance with this request I have prepared this article, with some haste, and to Mr. Enos and others, who have given considerable time and thought to the subject, am I indebted for references to the latest decisions concerning U. S. Land Laws.

Since not what ought to be but what is really established on the ground and contained in the plats returned by the Surveyor General is lawful, the surveyor should be governed by the Surveyor General's report for the district in which he is to work, with the exception of cases in which the marks still remain in the field; which of course are without dispute. Too much stress can not be put on this principle: that not what ought to be but what the first surveyors understood our land laws to be and what congress accepted from them *is law*. (U. S. Revised Statutes, Section 2396.) And if surveyors would look at the question from this standpoint there would be less controversy concerning our land laws; which to most surveyors appear very simple and direct. Yet the number of law-suits which occur concerning boundries in part indicate the errors made by surveyors, and very often these errors were over the most apparently insignificant, yet fundamental, principles. A little heed to the preceding caution and a few references to the acts of Congress on the method of subdividing a fractional section will be of as much use to the surveyor as any argument I can produce. I do not wish to trg to prove to the surveyor that some one method is correct and all others wrong, but rather to go as little into detail as possible giviny

a few methods for illustration and citing references on the points concerned.

The 2nd clause of 2nd section of act of February 11, 1805, states that the length of all lines actually run and marked in surveys returned shall be held and considered as the true length thereof; therefore in subdividing a fractional section the surveyor must first compare his chain with the established lines on the section and make it the same length, or what is the same thing apportion all distances accordingly.

In some of the first surveys of the state, which were mostly in the southern part of the state, the length of the north boundary line of a fractional section 1 say, was found by using the length of the southern boundary line of the section adjoining it on the north, section 36. The distance from the intersection of the north and south boundary lines of section 1 with the township line to the intersection of the north and south boundary lines of section 36 with the common boundary line were used to determine the length of the north boundary of section 1, and this distance bisected gave the ¼ section corner on the north boundary of section 1.

From about 1820, since which date most of the land in the state has been surveyed, the length of the north section and ¼ section lines of a fractional section were found by subtracting from the entire length of the north boundary of section 1, the ½ length of the south side of the same section. This was done by beginning at N. E. corner of section 1 and laying off the said ½ length and placing the ¼ section corner at this point; thus leaving for the length of the north boundary line of N. W. ¼ section the entire length of the north boundary of the section minus the ½ length of the southern boundary. These lengths may not always have been actually laid down, yet they were considered as the true lengths of these lines and returned as such. (3rd clause 2nd section Act of Feb. 11, 1805.)

Therefore in subdividing a fractional section it is first necessary to find the length of the north ¼ section lines as given in the plat in order to place the ¼ section corner just where it was intended to be by the original surveyor. To do this we will first measure the whole length of the north boundary of the section and place the ¼ section corner at the proportional distances from northeast and northwest corners of the section as indicated in the plat. Now run a straight line from here to ¼ section corner on the south and we have the half section line. In the same way the east and west half section line may be run and we have our fractional section quartered. Anomalous sections such as are bounded on one side by a lake, river or anything where the ¼ section corner on that side has not and can not be fixed, are provided for by 2d clause, 2d section of Act of Feb. 11, 1805. The part of the clause refering to anomalous sections, reads thus: "In those portions of fractional townships where no such opposite corresponding corner has been or can be fixed, the boundary

lines shall be established by running due north and south or east and west, as the case may be, to the water course, Indian boundary line or other external boundary of such fractional township." (U. S. Revised Statutes Sec. 2396.)

Acts of April 24, 1820, and April 5, 1832, provided for the subdivision of ¼ sections in half ¼ and quarter ¼ according to the principles of the 2d section of Act of Feb. 11, 1805. (U. S. Revised Statutes Section 2397.)

(Any of the above points of law will be found in U. S. Land Laws, 2d Vol., or in the Digest of U. S. Land Laws between sections 100 and 103.)

TOPOGRAPHICAL AND RELATED SURVEYS AS PROSECUTED BY THE GOVERNMENT.

By C. W. CLARK, LATE UNITED STATES ASSISTANT ENGINEER TO MISSISSIPPI RIVER COMMISSION.

Topographical surveys and surveys related thereto have been prosecuted by all civilized governments to a greater or less extent. By the related surveys, I mean such as are frequently prosecuted in connection with topographical surveys, or such as aid and increase the accuracy or value of them but are not absolutely necessary part of them—as geodetic triangulation and base line works, geodesic or precise leveling, and cadastral surveys. It is the purpose of this paper to give a brief review of the more important surveys under United States governmental organizations—paying more especial attention to the United States survey of the Northern and Northwestern Lakes and the survey of the Mississippi river, with which surveys the writer has been connected for several years. A few words will be devoted to the utility of such surveys and the necessity of geodetic and cadastral surveys of the United States.

Could you see a map of the United States which represented the important government surveys—the work of the different organizations being represented by different colors—you would see a band of one color extending from the northern coast of Maine and following the Atlantic coast to a point well down the eastern coast of Florida. Here there would be a short break, the band beginning again on the south east coast of Florida and extending along the gulf coast to a

point about 200 miles west of the Mississippi river delta. Here a longer break would be seen, but the band would begin again about 200 miles above the delta of the Rio Grande and extend to the delta. A band of the same color would be seen extending along the Pacific coast, from the southern coast of California to about the middle of the Oregon coast. The same color would extend in a band from Portland, Oregon, down the river to the sea coast, another from the mouth of the Mississippi river to Donaldsonville, La., still another would cover the Hudson river, portions of Washington Territory and portions of some of the eastern states would be covered by the same color. This color would represent the topographical surveys of the United States Coast and Geodetic Survey. A band of a different color would be seen extending around the shores of the great lakes bordering the United States, and part of the way down the St. Lawrence river. This color would represent the topographical surveys of the "Northern and North-western Lakes" under army engineers. This shore line developed would be longer than our developed Atlantic coast. A band of a third color would be seen extending from Grand Tower, Ill., to Donaldsonville, La.,—along the Mississippi river. This color would represent the topographical survey of the Mississippi river, under the Mississippi River Commission. A fourth color would be seen extending from the mouth of the Missouri river along its channel for over 1,100 miles, representing the topographical survey of that river under army engineers. A fifth color would be seen covering large areas of the western domain and portions of Texas, Kansas, Missouri, Alabama, Tennessee, Kentucky, Virninia, North Carolina and Massachusetts, representing the work of the Geological Survey, in connection with which topographical surveys were made. Four other colors would be seen covering large areas in the west representing the surveys of Wheeler, Hayden, King and Powell.

Aside from the above colors representing the principal topographical surveys, would be seen one which would represent triangulation work by the different organizations already mentioned, and by state surveys, over areas the topography of which has not been done. This color covers Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut ; portions of New Jersey, Virginia, North Carolina, Georgia, New Mexico, Arizona, Utah, California, Colorado and Montana ; bands of color would connect Toledo and Chicago, Chicago and southern Illinois, southern Illinois and St. Louis, Keokuk and Cairo and St. Louis and Kansas City. Having thus briefly noticed the location of these surveys we will consider separately the work of some of the organizations mentioned.

The topographical work of the surveys of the western domain and of the Geological Survey was made for small scale maps, and for a purpose which did not generally require minutia of detail, and hence the work was not of as high order as that of other organizations. This work has been executed over about one fifth of the United

States exclusive of Alaska. The limits of this paper will forbid giving a history of this work under Hayden, Wheeler, King, Powell and the Geological Survey, and although they have done a vast amount of work of much interest, only the methods of the recent topographical work of the geological survey will be briefly noticed: This includes the best work done by the organizations. The recent topographical work of the Geological Survey is based on primary triangulation of not much refinement as compared with the geodetic work of the United States Lake and United States Coast Surveys. They usually follow a quadrilateral or polygonal system, the triangle sides varying from a few miles up to 50 miles in length. Their base lines are measured with secondary base apparatus of the Coast Survey or with still less precise apparatus. Their triangles close within 8″ or 10″ and their more important bases are measured twice with a discrepancy not to exceed 2 inches. Latitudes and longitudes are also determined by astronomical methods, this work being about the same as done by the other organizations. With exception of this last work, their work serves only for map making. The primary triangulation observations are not sufficiently refined nor is enough attention paid to the geometrical proportioning of triangles to strictly class it as geodetic work; the probable error of a distance of 100 miles of the work being in some cases 300 feet. The elevations of the survey are usually based on lines of levels run by railroad and other surveys. The topographer entering the field of work starts from the primary triangulation points and executes a system of graphical triangulation, dividing the country surveyed into small triangles: he supplements this work by use of the gradienter, barometer, odometer, etc. In the delineation of the topography he uses constructional and graphical methods almost exclusively. The work is mapped to a scale of about 4 miles to 1 inch; in some special localities a scale of 1 mile per inch is used. While this work has been designated as of low grade it is not so designated in a critical sense; being for small scale maps and for purposes not requiring great refinement it would be a waste of time and money to introduce the refinements of the coast, lake and river surveys.

U. S. COAST AND GEODETIC SURVEY.

In 1807 the question of making a survey of the coast of the United States was first agitated. Little was done towards organization, however, until 1815, when F. R. Hassler was appointed superintendent. He first went into the field in 1817. In a short time the organization was disbanded and for ten years nothing was done. In 1832 Hassler was again made superintendent of the coast survey, which position he held until his death 11 years later. Hassler was an energetic and able man, and outlined the plan for a work—which being perfect and systematized by his successor, Prof. A. D. Bache—has become renowned for its practical and scientific value. Benjamin Peirce succeeded Prof. Bache in 1867. Carlisle P. Patterson

succeeded Peirce in 1874, and after his death J. E. Hilgard was appointed. This organization has done a vast amount of scientific work, and the annual reports contain many valuable papers. The geodetic work has been extensive and of great refinement, so that it serves for determining the figure of the earth as well as giving very accurately located points used as a basis for the topographical work, and on which may be based subsequent surveys. The more important base lines were measured with a complicated and refined apparatus, so that the discrepancy of two measurements of bases 4 to 7 miles in length was but a fraction of an inch. The triangles were carefully proportioned and the observations were so carefully made as to generally close the triangles within 1″, and on some reaches within ½″; the observations then being carefully adjusted to the most probable exact value. The refinement of this work was such that the probable error of a distance of 100 miles is only about 4 feet. From these geodetic points careful systems of secondary and tertiary triangulation were started and extended to cover the country between them. On these secondary and tertiary points the topography was based. The topography was mostly done by the plane table supplemented by the gradienter and telemeter. The elevations are largely based on geodetic lines of levels, from which ordinary lines are run when necessary. The work in some cases is lacking in the determination of many points of elevation, but the boundary lines of estates were mapped so that the maps in some cases partake rather of a cadastral than topographic character. The surveys themselves were not cadastral.

The plane table method for filling in topography is not meeting with nearly so much favor with engineers as is the stadia method, which will very probably be almost entirely used for such work in the near future. The plane table method is for most cases, however, far superior to the old, and now almost absolute, method of compass and chain or transit and chain.

LAKE SURVEY.*

The survey of the northern and northwestern lakes was begun in 1841 and from that time until its completion was under charge of army engineers. Capt. W. G. Williams was in charge from 1841 to 1845. The methods used were crude. Triangulation was done by vernier instruments, two readings taken of each angle. Topography was run by compass and chain lines with offsets. Base lines were measured by wooden rods about 10 feet long laid on stakes leveled for the purpose or on tightly stretched ropes. The hydrography was done by running on ranges and between buoys, the soundings being cadenced. From 1845 to 1851 the survey was under charge of Lieutenant-Colonel James Kearney. He used the same methods except that the triangulation was more carefully executed. Capt. J. N.

*Much of the material for this part of the paper is obtained from "Professional Papers No. 24 Corps of Engineers, U. S. A."

Macomb had charge from 1851 to 1856. He introduced astronomical work but it was not very accurately done. An improvement in measuring base lines was made; an apparatus was used, made of two bars, one of iron and one of brass, firmly joined at one end and with a compensating lever attachment at the other, so as to give about the same length at all temperatures. Primary triangulation was begun with fairly good instruments, but no lines were used longer than 20 miles. The angles were read by repetition, but no systematic method of observing was used so as to eliminate instrumental errors. The hydrography was done by running on ranges and some soundings located by sextant angles. For a short time in 1856 and 1857 the survey was under charge of Lieutenant-Colonel James Kearney, but he was soon succeeded by Capt. Geo. G. Meade, who fully developed the hydrographic work. The inshore hydrography was done from small cutters or large skiffs and extended from the shore to points one-half mile from shore, or to greater distances if the water was so shoal as to prevent the steamers from beginning work at that point. The soundings were taken on lines between located objects on shore and located buoys,—or between located buoys. The soundings were taken at given intervals of time and were for the most part cadenced on the maps. The offshore hydrography was taken from steamers, beginning where the inshore work ended. Soundings were taken on lines ½ mile to 1 mile apart, approximately normal to the shore, and extending 10 to 12 miles out from shore. The soundings were located by two or three observers with theodolites at located shore stations 4 to 8 miles apart. They took angle readings to the steamer at the instant the soundings were taken. The locations thus made were sometimes checked by sextant readings taken on the steamer between located objects on shore.

From 1864 until 1870 the survey was under the charge of Gen. W. F. Raynolds. The astronomical work under him was faulty in not having the personal equation of the observers sufficiently well determined. The triangulation was further developed, but no systematic method of observing was used to eliminate errors. The largest triangle of the lake system was measured in 1865 on Lake Superior, the three sides being respectively 92, 93 and 101 miles in length. From 1870 until the close of the work 1881, the survey was under the charge of Gen. C. B. Comstock. The stadia method of doing topography was perfected under him, and attained to a standard that had never been reached before. He also perfected the system of measuring primary angles, and introduced better instruments for the purpose. Under him the measurement of base lines attained to a greater precision than had been reached in this country. He also introduced precise leveling on the survey. The secondary triangulation, stadia work, and precise leveling were further developed on the survey of the Mississippi river, and will not be noticed here excepting to state that the triangles of the secondary work closed with an average error of about 14″—vernier instruments reading to 10″ being

used—and the average error in reading distances with the stadia was about 1 meter in 650 meters. The primary triangulation was required to be of such precision as to close the triangles within 3″—they generally close under 1″. Starting from and connecting accurately measured bases from 150 to 300 miles apart, these triangles varied in size from sides of a few miles in length up to 100 miles, but commonly being 20 to 50 miles. The instruments used were non-repeating and were read by two or more micrometer microscopes to single seconds. Supposing that the stations to be read to from any point are numbered 1, 2, 3, 4 . . . . . around the horizon in order, then the best method that was used for observing was to read consecutively to 1, 2, 3, 4 . . . . . . 1 (thus closing the horizon) then immediately reading in reverse order 1 . . . . . . 4, 3, 2, 1. This constituted what was called a set of readings. The telescope was then transited and the same programme followed for another set. After each set the horizontal circle was shifted a number of degrees inversely proportional to the number of sets of angles to be read (if n = number of sets then shift 360°÷n.) This method of observing almost eliminates instrumental errors and twist of station. The instruments used were of the most refined character, and careful series of observations were taken for determining their constants—as errors of graduation, ellipticity of pivot, periodic errors etc. In one case that I call to mind, an instrument with 10 inch circle was found to have an error of graduation of not more than .00005 inches in placing any graduation mark. This instrument was made by Repsold. Primary bases were measured with two kinds of apparatus. The earlier bases were measured with a Bache-Wurdemann apparatus, and the later bases by a much better apparatus made by Repsold. This later apparatus is the most precise in this country, but space forbids a description of its construction and the method of using it. In 228 triangles measured on this survey 133 closed under 1″ in error, only one case reached 4″ in error and but very few reached 3.″ These triangles include some that were measured with comparatively poor instruments. Eight primary bases were measured and to show the precision of this work the probable errors of their length are here given.

Keweenaw Base.—On Lake Superior; length of base about 5½ miles; probable error in length ± 0.349 inches.

Minnesota Point Base.—West end of Lake Superior; base about 3.7 miles long; probable error of measurement ± 0.45 inches; difference of measured length and length computed from Keweenaw base 2.55 inches; probable error of computed length 2.97 inches; distance between bases 240 miles.

Fond du Lac Base.—Ten miles from Fond du Lac, Wisconsin; base about 4.6 miles long; probable error of measured length ± 0.45 inches; difference of measured length and length computed from Keweenaw base 1.16 inches; distance between bases 320 miles.

Sandy Creek Base.—East end of Lake Ontario; 3.4 miles long; probable error of measured length ± 0.21 inches.

Buffalo Base.—East of Buffalo, New York; 4.2 miles long; probable error of measured length ± 0.3 inches; difference between measured length and length computed from Sandy Creek base, 210 miles distant, is 1.44 inches.

The above bases were measured with the Bache-Wurdemann apparatus. This not being satisfactory was replaced by the Repsold apparatus which was used for the Chicago, Sandusky and Olney bases.

Chicago Base.—About 14 miles south-west of Chicago; length about 4.6 miles; probable error of measured length ± 0.023 feet or $\frac{1}{1,052,200}$ of its length.

Sandusky Base.—Between Sandusky Bay and Lake Erie; length about 3.8 miles; probable error of measured length ± 0.0178 feet or $\frac{1}{1,148,600}$ of its length, or at the rate of 1 foot error in 217 miles.

Olney Base.—Southern part of Jasper County, Illinois; length of base 4.1 miles; probable error of measured length ± 0.021 feet, difference of measured length and length computed from Chicago base 0.199 feet; distance between bases 200 miles.

SURVEY OF THE MISSISSIPPI RIVER.

The Mississippi River Commission was organized under the provision of the act of Congress of June 28th, 1879, and is composed of four civilians and three army engineers. The Commission has been composed of the following men: Gen. Q. A. Gillmore, Gen. C. B. Comstock, Maj. Chas. R. Suter—army engineers—and Maj. B. M. Harrod, Prof. Henry Mitchell, Capt. Jas. B. Eads, to April 4th, 1883, Benj. Harrison to March 3rd, 1881, Judge Robert S. Taylor from March 4th, 1881, and S. W. Ferguson from May 21st, 1883. The work under this commission has consisted of river improvements and surveys of the river. The field work of this survey has been prosecuted by different parties that may be classified as follows: (1.) Secondary triangulation parties; (2.) Precise leveling parties; (3.) Topographical parties; (4.) Trans-alluvial leveling parties and (5.) Gauging parties. As the topographical work was entirely based on the secondary triangulation, this triangulation was more carefully executed than is ordinary with such work. The triangle sides varied from about ½ mile to 20 miles in length. Triangles were required to close within 6″—in practice they were generally closed within 2″ or 3″. The bases were measured with a secondary base apparatus or with a steel tape. The tape used for this purpose was 299 feet long and was stretched over stakes 25 feet apart driven to grade. A uniform tension was obtained by stretching with a weight fastened to the tape by a wire, which passed over a large pulley on an auxiliary stake. One base measured with this tape was over two miles in length and a discrepancy of 4 inches in two measurements obtained—a large discrepancy compared with that of other bases measured with the same tape. Other bases gave discrepancies as follows: One base 1½ miles long—discrepancy 0.08 inches; one base 1¼ miles long—discrepancy 0.8 inch; one base nearly

two miles long—discrepancy 0.06 in. These results show that very good work for secondary bases may be done with the steel tape, if its length is accurately known and its coefficient of expansion determined. Octagonal and cylindrical targets were used on most of the work, and in some places the results were somewhat vitiated thereby, as the phase of such targets is considerable. Flat targets would doubtless have given somewhat better results on some sections. The following errors of length were found to obtain on this work : From Keokuk, Ia., to Louisiana, Mo., 25 triangles—discrepancy in length, 1 in 25,000—in azimuth + 4″.8. From Louisiana, Mo., to Grafton, Ill., 22 triangles—discrepancy in length 1 in 13,000—in azimuth—10″.2. Grafton, Ill., to St. Louis—35 triangles—discrepancy 1 in 30,000. St. Louis to Chester, Ill.—23 triangles—discrepancy 1 in 100,000 in length and + 9″.3 in azimuth. Chester, Ill., to Cairo, Ill.—discrepancy 1 in 6,000 in distance and + 21″.8 in azimuth. From Helena, Ark., to Greenville, Miss—219 triangles—discrepancy 1 in 1,000. Greenville to Saint Anderson—33 triangles—discrepancy 1 in 15,000. Greenville to Prentiss—93 triangles—discrepancy 1 in 13,000. The comparatively large errors of the work on some portions of the lower river has been attributed by some to errors of phase. It seems improbable that the phase would vitiate the work to that extent. Quite probably a portion of the errors are due to the adjustments rather than entirely to the field work.

The precise level work done with this survey extends from Chicago to Keokuk, Ia , from Keokuk to Greenville, Miss., and from Carrollton, La., to Biloxi, Miss.; a total distance of over 1,200 miles. The levels were duplicated on all the lines. The method of observing varied somewhat on the different lines. In some places two observers ran the line in the same direction, in other cases the two observers ran over the line in opposite directions, and in other cases one observer did the work on a stretch running over it in both directions. It seems that the latter method is preferable as it eliminates errors that may not be eliminated by the first two methods. Very delicate Kern levels were used with extra powerful telescopes.

Speaking rods were always used, and the rod reading taken on each of three horizontal wires. These readings were reduced to the imaginary collimated wire and the mean taken. The difference of the wire readings was utilized to determine distances of fore and back sights, the sums of which were kept balanced. In some cases the recorder read the level when the observer took the rod readings, in other cases the observer read the level by means of a mirror with one eye while taking the rod reading with the other. Permanent benches were frequently made for bases for ordinary levels. This work connects with Coast Survey and Lake Survey levels to form a continuous line from the Atlantic Coast to Chicago, Chicago to Keokuk, and Keokuk to the Gulf of Mexico. A check on the work was thus obtained by comparing mean tide elevations of the Gulf and the Atlan-

tic. This check and a check at St. Louis by a Coast Survey line from the Atlantic, show that the errors were less than 1 ft. for each 1,000 miles of line run.

The work of the topographical parties consisted briefly of carefully running the shore line; of making a survey of $\frac{3}{4}$ miles to $1\frac{1}{2}$ miles back from the river, locating all natural and artificial characteristic features, and locating enough points in elevation to fix the characteristic 5 ft. contours; of running out old lakes, rivers, prominent bayous, levees, &c., that are in proximity to the river; of doing tertiary triangulation when necessary; of running a line of ordinary levels down each bank of the river and out to stone line bench marks (stone lines were normal to river and placed about 3 miles apart, a line having 2 B. M's. on each side of the river); and finally of running lines of soundings normal to the current and $\frac{1}{4}$ mile to $\frac{1}{2}$ mile apart.

The shore line and topography is run with a transit which has a vertical circle or arc, a telescope of high magnifying power and usually with inverting eye piece. Azimuths are carried continuously from stake to stake so that all readings are on azimuth. Distances are read by the interval on a graduated rod superimposed between two horizontal wires in the telescope. (The best interval to use is 2.5 ft. per hundred meters or about 0.8 ft. per 100 ft.). The rods are marked by figures about $2\frac{1}{2}$ in. wide so arranged that the even meter distances are read directly, and for ordinary distances the nearest meter is easily estimated. Elevations are carried by reading vertical angles. The azimuths and distances are frequently checked on the triangulation stations, and the elevations checked on bench marks or turning points of the levelers. Distances of $\frac{1}{2}$ miles are quite frequently taken at one reading in favorable weather, and in a few cases distances of nearly $\frac{3}{4}$ miles have been read with good results. Where circumstances will permit distances of about $\frac{1}{4}$ to $\frac{3}{8}$ miles between stakes are best. There is seldom any trouble in making circuits of 1 to 20 miles close with sufficient accuracy for large scale maps. For the long circuits or over rough ground this method equals or exce s ordinary chaining in accuracy, and makes a very great saving of time. Elevations carried by vertical circle readings seldom reach 1 ft. error in circuits of 1 to 5 miles, with an experienced topographer. About 2,800 square miles of topography has been done on the Mississippi river by this method.

Tertiary triangulation is only done where secondary triangulation is wanting, or the secondary stations lost so that a sufficient number of checks for the topographical work cannot be obtained. Almost the entire reach of work done in 1883 and 1884 had to be accompanied with this tertiary work. In the fall and winter of 1884 the author executed a tertiary triangulation on two reaches of the river covering a total distance of over 100 miles. As this is a fair sample of the tertiary work done on these surveys a short notice will be given of it. The targets used were ordinary poles blazed or with

a white cloth wrapped around a portion of the pole. Three sets of observations were taken on each angle, a set consisting of a reading in a positive and a negative direction. The circle was shifted 120° between each set. The instrument was kept in good adjustment, and the telescope was not transited between sets unless the stations varied greatly in elevation. Observations were taken irrespective of atmospheric conditions. The targets were often disturbed giving rise to errors which could not always be corrected. When target corrections could be obtained without much waste of time they were applied if amounting to more than ½″. The instrument was always used as a non-repeater. About 75 triangles were measured with a Wurdemann instrument reading by verniers to 10″; the average error of closure was 10½″. About 80 triangles were measured with a small Gambey Wurdemann theodolite reading by verniers to 5″. The accumulated errors of azimuth over each of the two reaches was about 30″. The discrepancy between the secondary and the tertiary triangulation on the river has varied from 1 in 1,000 to 1 in 46,000.

The ordinary levels were carried down each bank of the river to give elevations for checking stadia elevations, to determine height of water on the lines of sounding, to get river slope for reducing the hydrography, and for establishing permanent bench marks set on lines normal to the river about 3 miles apart. The levels were based on precise level work, and frequently checked on precise bench marks. The two lines frequently checked each other by river crossings. These crossings are made by taking a series of 6 to 10 simultaneous observations by two observers, one on each bank; the observers then changing positions and taking another series. Generally special targets have to be used on the rods, as these crossings are sometimes ¾ miles or more in length.

The soundings are generally taken from a six-oar cutter, containing 2 observers, 1 recorder, 1 leadsman and 6 oarsmen. The boat is kept on range, as nearly as can be, between flags on each shore. Every third or fourth sounding is located by sextant angles, taken by the observers between located signals on shore, care being taken to so select signals that revolving angles are avoided. Soundings are made at intervals of 30 or 40 meters. The elevation of the water surface at time of sounding is determined for each line by means of the levels. From these elevations and the local gauge and river slope determinations the soundings are reduced, for each detail sheet, to the mean stage that obtained during the time occupied in surveying the portion mapped on such sheet.

This paper has attained to such length that a description of the trans-alluvial and the gauging work must be omitted. It was intended to briefly notice the methods of office reductions and map making, but space forbids.

Many persons fail to see the utility of government surveys of this class, and are disposed to look upon them as means of wasting public money. Perhaps I may be pardoned if this paper is lengthened

in order to say a few words regarding their utility, and to speak briefly of the necessity for a complete geodetic survey of the country.

The hydrographic and shore line work of these topographic surveys are a necessity to navigators for the safe navigation of the great lakes and the waters bordering our Atlantic, Pacific and Gulf coast. The same work on the Mississippi river has been valuable to steamboatmen. Complete topographic surveys in the vicinity of our coast lines, besides being of great local benefit and an aid in many cases to navigators, would be of inestimable value in case of war with foreign countries.

The topographical survey of the Mississippi river is a necessity for the solution of certain problems in river physics. The survey is so made that the river of to-day can be compared with the river of 10, 20, 50 or 100 years hence. One of the greatest problems of the day for engineers to solve is that of controlling our silt-bearing streams so as to prevent destructive overflows, and so as to make navigation easy and safe at low stages of water. Good navigation on the Mississippi river at low stages would be worth millions of dollars annually to the western and southern states. The engineers to-day who are trying to improve the Mississippi river are confronted by problems which will probably take years to solve, the solution of which would be comparatively easy if good topographic and hydrographic maps made for each decade of the past 100 years were in existence, and so made as to be compared accurately with each other; and if gauge records for that period were available.

The geodesic levels besides being a necessity for very accurate topographic work, have given the exact elevation, above sea level, of many points in portions of the country. These elevations will be utilized in the future for engineering works and surveys of various kinds. The astronomical work and geodetic triangulation has given very precise determinations of the latitude and longitude of many points in some parts of the country, and hence their relative location is known.

If this country continues to advance as rapidly as at present, and property continues to enhance in value, there will soon be demanded a class of surveys which will probably become either national or State in character. These are cadastral surveys or accurate surveys of land. Such surveys will be costly but when made will save immense amounts of litigation. When made they should throughout the country have one basis, and not one section of country have one monument or point of reference and another section a monument of reference disconnected with the first. In short they should be so made that if every surveyor's stake or corner stone or mark throughout the country was destroyed, the lines of the survey could be accurately re-run so that justice would be done to all parties. This can only be done by basing them on geodetic surveys. It is high time that these geodetic surveys were systematically begun and carried over the entire country where they are lacking. Their need is now

beginning to be felt and it will take years to complete them. If the general government does not soon take up the work, will not Illinois lead the movement by beginning a State geodetic survey? When this work is in progress there should be a little more work done in connection with it than has been customary; that is from or in the vicinity of each goedetic station a short base line should be carefully measured with government standards, the ends fixed with permanent marks, and the azimuth carefully determined. The results should be then furnished to all the local engineers and surveyors; they then could all have access to correct standards of length which most of them have not at present. Such bases would be of great value for secondary or tertiary triangulation for the cadastral surveys and for other surveys and engineering work.

DISCUSSION.

Mr. D. L. Braucher—I fail to see the value of a geodetic survey in determining ordinary corners and land boundaries.

Mr. Clark—It would be of no value for that purpose, but when the present boundary lines are found and accepted as true boundaries, then they could be referred to the points established by the geodetic survey and so be preserved for the future.

ROAD IMPROVEMENT.

By C. G. ELLIOTT, of Tonica.

There are many factors which enter into this problem. Some of them are peculiar to our State, some to the various localities, while others become complex by reason of the ever capricious public mind in different sections. Public opinion is perhaps the most fickle and uncertain of all these factors—in short it is the variable quantity in road improvement mathematics. Good roads come under the class of universal wants of at least a large portion of mankind. Some do not know how to supply this want, others know how but are not willing to pay the price, while still others have visionary schemes by which our much abused country thoroughfares can be made to take upon themselves the completeness of city boulevards.

The way to obtain good roads is to improve the old ones, rather

than to supplant them with something entirely new ; to use what we already have as a step to something better, rather than to discard the whole. We must use the material we have at hand and the public funds that can be obtained for this purpose in such a way that our roads, even if not made perfect, will be permanently improved. Whatever is done should be so done that it can be built upon and added to, thus making each successive step an improvement.

The Foundation.—The basis of all road improvement in our soil is drainage, both surface and subsoil. It is now no longer doubted by those who have tried it, that the best plan for obtaining a good road base or foundation is by under-drainage. The road surface may possess different degrees of excellence, but it is always better with an under-drained base than without one. To obtain this first excellence, please note the following manual: If an embankment or grade does not already exist, one should be made, the crown of which should be two feet higher than the bottoms of the broad ditches at the sides. This embankment should be twenty feet wide, and eight inches crowning. The ditches at the sides should be so graded as to readily carry all flood water into the nearest watercourse. This base, as now constructed, should be supplemented by under-drains made of first-class drain tile. When the surface ditches have removed all of the water which will readily flow away through them, the soil will still be sufficiently saturated to make a spongy and unstable base for an embankment. Place parallel lines of tile about three feet below the bottom of the surface ditches along the base of the embankment and they will thoroughly drain the lower stratum of soil for the entire road to a depth of nearly five feet below the road surface. As far as the sub-grade of the road is concerned, this plan, when well carried out, leaves nothing to be desired. The surface, however, which has absorbed water from the rainfall, and retains it by reason of its puddled condition, is faulty and can only be made complete by adding a dressing or covering which shall be both durable and impervious to water. The under-drainage of a road will ordinarily cost about four hundred dollars per mile and for the amount expended no better improvement can be desired for ordinary roads than this. No smaller than four-inch tile should be used and as much larger as the locality and length of the lines will require. It should be said in this connection that the Henning Pipe Line Ways Co., of Waterloo, Indiana, have a patent that covers the use of tile for road drainage.

Catch Pits.—We may adapt this plan to stiff and retentive clays by making catch pits at such intervals as seem necessary in order to give ready entrance of surface water into the tile drains. These may be simply open pits over the tile filled to the surface with small stone or brick bats, and are a valuable acquisition to the system of road drainage. The village of Ashkum, Ill., has drained her main streets in this way, going so far as to fill the entire length of the ditches above the tile with broken stone, and the result is in every way satisfactory. This is the plan for making roads out of our common soil, and that

is what ninety nine out of every one hundred miles of road in this State must be made of for years to come. This statement, may not be of very great moment to engineers, but to the traveling public it is of great importance.

The Surface.—As previously stated, the surface of a dirt road is far from perfect, but it can be made and kept much better than it is ordinarily found. Keep the surface crowning, and as hard as possible when the earth is dry. The timely use of road machines made for this purpose will make this part of the work a light task. The difficulty is, however, to get such work done at the proper time. If due care is taken with the surface, most of the rainfall will be shed off towards the side ditches and thence be quickly removed. When there are extended rains and continued travel at the same time, or when the frozen road surface is thawing in the spring, then is experienced the necessity of a more permanent covering. The work already described has made an admirable foundation for a gravel covering and it is desirable to complete the road in this way whereever the proper material is accessible. Formerly a depth of fifteen or twenty inches of gravel was considered necessary for a good road; but with thorough underdraining ten or twelve inches has been found sufficient. The following is a description of a two mile section of one of the leading roads near Ottawa, the county seat of LaSalle County, Illinois.

The general plan of the road is a crowning earth embankment twenty-seven feet wide, with side ditches about twenty inches deeper than the center surface line. In all flat parts of the road, a drain of four-inch tile is laid two feet deep lengthwise along the center of the road, and discharges into the side ditches at convenient places. Upon the bed thus prepared, a covering of gravel one foot thick and nine feet wide is placed and left crowning upon the surface. Earth from the side ditches at this stage of the work is now drawn up to the edge of the gravel to one-half its height to prevent the gravel from spreading. This makes a single track gravel road with a dirt road on each side of it. It cost $1,500 per mile, the gravel being hauled two miles for the most distant part, and all of it up a hill with 100 feet rise. After a use of three years it remains in good repair and seems to please the public.

The roads in the level counties of our state, of which Ford, Livingston and Iroquois are examples, are a problem by themselves. Under the present system, the road ditches are made the drainage channels for the adjoining farms, and are immediately connected with private land drainage. When those used for main channels have been deepened, it will be possible to lower the water level of the whole country affected by them, so that farms and roads will be alike benefited. As far as my observation and experience go, it is difficult and expensive to secure a good gravel road without close attention being given to sub-drainage. The more absorbent the soil is, the lower must the soil water be removed. This depth I believe to be

five feet in our open porous soils, and not less than three feet in retentive soils.

Culverts—Small bridges and culverts are often a continued expense because of poor construction. It is a common opinion that anything made of stone will be permanent, but unless such structures are well made, wood is just as desirable and much cheaper to renew. Our abutments for small bridges will bear a great improvement, for many of them are no better than ordinary cellar walls made of small stones, lime mortar, and backed with spalls. The mortar soon crumbles, the walls underwash, and the supposed durable stone work becomes a worthless mass. What is the remedy? First, securely pave the water way with stone so that the abutments cannot underwash. Second, at least one-half of the stone should have a broad bed, and a thickness of from five to eight inches. Good hydraulic cement mortar should be used, and, above all, the back of the walls should be well covered with mortar to prevent the entrance of water from the earthwork, and thereby ward off an agent of certain destruction to the stability of stone work.

An improvement over the small box-culvert is the sewer-pipe culvert, which has been introduced in many localities, and when of proper capacity and well secured in place, it is preferable to any other kind. In setting these pipes, the extreme ends are often secured by light stone walls, which also serve the purpose of holding the earth embankment above the pipes. These walls, like the abutments previously mentioned, soon give way. A better and cheaper plan is to use stone rip-rap about the ends of the culvert, taking care to make the culvert long enough so that a slope of one to one may be given to the rip-rap without infringing upon the width of the road track. This will serve its purpose, as well as make a suitable retaining wall, and be less liable to injury from frost and road repairs.

Memoranda.—The following is a brief statement of a few of the rules which the writer is accustomed to use in determining improvements for common roads :

For thickness of abutment walls, four-tenths of vertical height. Face batter one and one-quarter inches per foot. Paving for culvert water ways, ten to twelve inches thick, made by placing stones edgewise in courses crosswise of channel and inclined in the direction of the current.

Area of water-way in square feet should equal one and one-half times the square root of the acreage having its drainage through the culvert in cases where the land is moderately undulating.

Least depth of covering upon sewer-pipe culverts two feet.

Thickness of gravel upon a well-drained sub-grade or base twelve inches.

Sanitary Effects.—It has doubtless occurred to you already that drainage has been presented as the *multum in parvo* of road making, the actual foundation upon which depends the success of road construction. If so, well and good. There is an attendant advantage

in the plan recommended, which is equally important, and that is the additional healthfulness which must result to our own homes. Though it is not necesssrily so, yet it is a fact that where roads are provided with surface drainage only, there usually remain basins and badly graded ditches which retain water for days and weeks at a time. Ponds by the wayside do not get sufficiently drained, and so remain to defile the otherwise pure air with the effluvia arising from their drying and decaying vegetation. Most disagreeable and even dangerous do these silent agents prove to be, if, as is often the case, a dwelling is located near some poorly drained portion of road. Road under-drainage removes this danger from the immediate vicinity, and adds, as it were, a voice of encouragement to the adjoining land owners to continue the work begun.

Road Engineering.—As yet there is little asked of us in the line of road engineering. Every board having this matter in charge consider themselves qualified to plan and direct all road improvements required of them with the exception, perhaps, of an occasional piece of heavy work when a surveyor is called to set a few stakes. The road jobber or contractor, being a *practical* man, is conferred with, when consultation and advice are thought necessary, and given entire charge of the work. In fact, it is common to advertise for bids on work, requiring the contractor to make his own specifications. As a consequence of this method of procedure, the amount of public money paid out for poor work under the name of first-class work during the last twenty years has been enormous. The engineer may have opportunities for influencing the public toward correct and wise ideas upon the subject of roads, and thus be instrumental in gradually bringing about an improvement; but he need expect no remuneration, not even thanks. The public expect to pay their lawyer and physician for counsel, but not their engineer for a similar service, especially when it is upon a subject of no more magnitude than that of common roads. Our work lies largely in the direction of informing and educating the public mind upon this subject—a work not especially profitable to us, but we trust it will be to the general public. Much reform is required in this state in the management of roads, but this will be brought about when we all come to understand what a good road is, and how it may be obtained.

DISCUSSION.

Prof. Morrow—I regard the subject of road improvement one of the most important questions now before the commonwealth of this country. It is to be solved only by tile drainage, and a good foundation kept dry to a sufficient depth. I have seen many instances of the value of surface catchpits to take water quickly from the surface. A patent intending to cover the use of tile in the drainage of roads in its broadest sense, would not, I think, be sustained by the courts.

The roads should be kept in good condition by continual repairing rather than by periodical onslaughts.

Mr. Sager—I endorse Mr. Elliott's paper. I appreciate the difference in keeping in good condition the roads of this state and those of Ohio, where we have plenty of gravel for covering our roads. Broken stone is used with good effect in our state where we do not have good gravel, but in all of these plans we must have drainage and a good foundation.

Mr. Hodgman—I think that the first question is to get public sentiment right. In my state (Michigan) we must look well after the location of roads. Public sentiment would require us to locate on section lines while that would often be very expensive, not only to construct, but to travel on account of hills and grades.

Mr. Hammett—The present system of farmers working out their road tax is exceedingly faulty.

Mr. Ela—As long as road commissioners think their own knowledge of road improvement superior to the engineers, it will be very difficult to make much progress.

STORAGE RESERVOIRS FOR FARMS, AND THEIR EFFECT UPON CLIMATE.

By DANIEL GORDON, of Moline.

On many farms in the valley of the Mississippi river and its tributaries, away from lakes or large streams there is scarcity of water for domestic animals during dry seasons of the year. To supply this want wells are constructed and water raised by wind power or by the more laborious mode of hand pumping. Where the land is high and uneven enough, the plan of impounding the rain water in surface reservoirs is suggested as a substitute for this method; I know of but a single instance of a reservoir for farm use which has been constructed somewhat after the manner hereafter described, and for ten or twelve years it has afforded that farm an excellent supply of stock water.

Select some ravine or hollow with not too large a water shed of meadow, woodland or tile-drained fields. Across this ravine construct a dam of earth scraped from the banks or preferably in many cases from the bottom of the intended reservoir. It will usually be well to form this dam on the line of a desired roadway from one part of the farm to the other. The travel over the embankment will tend to compact the earth. A most important part of a successful reservoir of water is the waste way to carry the surplus water during heavy and long continued rains. This should be laid through the dam and be secure from washing out. It should be at a sufficient distance below the top of the dam, and of sufficient size so that the water will never rise high enough to flow over the dam. Great care should be taken in the construction of this waste way; as from overflows or the washing out of a badly constructed conduit is the great danger of the destruction of the dam. The area of the water-shed compared with the surface of the proposed pool should be carefully considered. As much depth as practicable should be obtained. To keep the water clean and pure, the conditions of the situation must be studied. Stock should be fenced away from the pool, and all drainage from stock yards or other foulness be carefully excluded. To supply water to stock, a pipe from the pool should be laid to a convenient point for a hydrant from which water can be supplied to troughs for stock. In some cases by collecting the water on the highest part of the farm it may be piped to the house, the barn or the lawn, and forced by gravity to serve for fire protection as well as for other purposes.

To obtain pure water as already intimated, it should be collected from meadow, woodland, or from the drains laid through cultivated land. When collected in the reservoir, means of keeping the water pure will require attention. More or less aquatic vegetation will appear, and aquatic insects will multiply, feeding on the decaying vegetation. To keep these down, the owner of the pool spoken of introduced sunfish, the presence of which in large numbers kept the water clear. Doubtless a more valuable variety may be found when wanted. When practicable these reservoirs should be as much as twelve feet deep, so that they will during the driest weather not loose more than one-third of their depth by evaporation and use. The suggestions just offered will not suit all situations or purposes, but may serve as specifications to modify or depart from as circumstances require. The possession of a pool of clean deep water on a farm affords an opportunity of securing a supply of ice for use during the heat of summer. In many cases it may be utilized for fire protection.

The maintenance of a limited water surface on each farm where such a reservoir as described has been constructed, would compensate in its atmospheric effects during hot weather for the drainage of a much larger area of wet land. In the new or wild condition of the lands over a large portion of the Mississippi valley a large percentage, perhaps as much as ten per cent. of the surface of the country was wet. The water collected in basins or flat lands and sloughs.

The flow of the water therein being obstructed by grass or other material, the water to a large extent evaporated, furnishing vapor for local rains; the effects of which reached from one period of general rain to another. It is upon the supply of local moisture falling in showers or in dews upon the growing crops that much of the success of the cultivator of the fields depends. The abundant vapor from tropical seas may at times be driven over the continent and be precipitated in great storms over the land, but between these wide-spread rains there may be such protracted droughts as to render unavailing all the labors of the husbandman. It is, I believe, the uniform testimony of the pioneers of this state, that the climate has changed since the first settlement of the country in respect to rains. The dry seasons are more protracted and drier than formerly. This is accounted for by the fact that the surface of the land is denuded of grass, and that the removal of obstructions permits the rapid flow of rain water into the water courses, to the rivers, and to the sea, instead of its sinking into the ground or being evaporated from the surface as formerly, to condense and fall in rains again and again.

Vast areas in all quarters of the globe are well nigh uninhabitable by reason of their aridity; and lands once the seat of mighty empires have become deserts, supporting only wandering tribes of barbarians who now live by the pasturage of the scanty vegetation of countries once supporting populous cities. In our own country, away from the influence of the lakes, droughts are becoming frequent and injurious. The water which falls upon the surface during general rains immediately runs into the ravines, working out gullies through the cultured fields and down the ravines, carrying away the most fertile parts of the soil into the rivers. The creeks formerly running through the year with clear water become for a time raging torrents of muddy water. The large rivers rise to unprecedented height, carrying terror and ruin to extensive tracts of fertile country. In a short time after the storm is over, the small water-courses run dry. The large rivers shrink to a degree hitherto unknown. The high water mark grows higher, and the low water mark lower, until navigable rivers become rivulets. The Ohio river rises sixty-five feet, and by its overflow carries away great numbers of dwellings, and does incalculable damage. Then its tributaries dry up to such an extent, as in West Virginia, that domestic animals perish for want of food and drink, and the people are swept off by epidemic disease, caused by the use of poisonous mineral waters. These are simply instances of the tendency of things throughout the country. The springs dry up; the wells fail, and farmers have to drive their stock to distant streams for water. The produce of the fields is diminished or destroyed by drought. A season of heat and dust quickly succeeds deluging rain. Every ditch and drain hastens and aggravates the formation of devastating floods immediately after a general rain, to be followed all the sooner by injurious drought.

These tendencies and effects so detrimental to the country, being

an unthought-of incident of the cultivation and drainage of the land, can when understood be counteracted to any necessary extent, by impounding on each square mile of territory as large or a larger per centage of the rain fall as was held in the natural reservoirs of the country previous to its settlement. The distribution of water surfaces over the country during the heated term of summer would transform a part of the excessive solar energy into the work of raising water to sprinkle on the crops instead of expending all of it in parching them up, and by such water-lifting add greatly to the profit and comfort of the people. It may seem unnecessary to economize solar energy, but it is worthy of thought whether it be possible to make arrangements so that that energetic worker, the sun, shall serve us rather than to work upon us as his victims. If we let the country get as dry as Sahara, he will occasionally bring us from the far off Gulf of Mexico clouds charged with moisture and electric energy ; and as they roll over the super-heated country they too often come with a cyclonic twist that sweeps all human work from their path with a facility that appalls every beholder.

To construct surface reservoirs large and small on the thousands of square miles of territory drained by the Mississippi river is a great work involving a large expense. But a greater difficulty will be to induce the millions of men resident thereon to individually engage in such work on their respective lands, and to lead them to favor the policy of legislation in behalf of such works to control such surplus waters as are beyond the province of individual effort by the State and general governments respectively as the public and general good require. But thorough information as to the necessity of such works, and appreciation of the benefits of so controlling storm water as to prevent droughts and floods, and a reasonable belief in the feasibility of its accomplishment will bring it about. When the people will it, there will be ways of doing it. Let the United States preserve, improve, and extend all the large natural reservoirs in its domain at the head of navigable rivers which run through several states, and where natural reservoirs are wanting, construct artificial ones, acquiring title to lands in the older states for that purpose. The water impounded in Minnesota tends to diminish a flood on the lower Mississippi ; and being gradually discharged in a dry time helps preserve continuous navigation in the upper Mississippi river. The heads of the Ohio, Cumberland and Tennessee rivers on the east ; the Missouri, Arkansas and Red Rivers on the west of the Mississippi would require like improvement. Let the several states legislate for the improvement of water surfaces within their borders and encourage the construction of reservoirs by individuals and municipalities.

Let the great problem of water supply for agriculture in regions subject to drought engage the thought and investigation of the civil engineers of the country ; let them discuss the possibilities and limitations of the improvement of climate by the maintenance of water surfaces throughout the country.

DISCUSSION.

Mr. Clark—I think that the storage of water in reservoirs would not have much effect upon navigation except in the upper waters of streams. It seems to be a fact that the high-water mark of our streams is higher and the low-water mark lower than formerly, and that, if possible, something should be done to avert these evils. Europe is experiencing like results in her central portion, but it is attributed to the destruction of the forests.

WHAT ARE THE PRINCIPLES AND RULES OF LAW THAT ARE TO DETERMINE THE EXTERIOR BOUNDARIES OF THE GOVERNMENT TOWNSHIP?

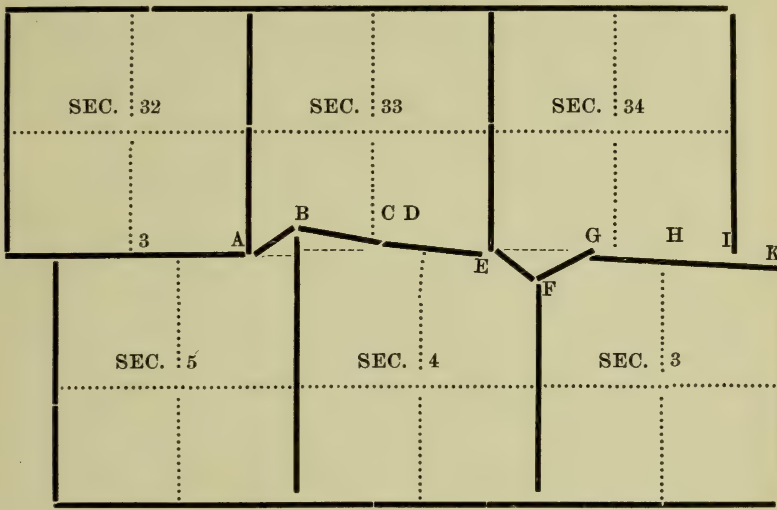
By Z. A. ENOS, of Springfield.

In looking over the published proceedings of the Michigan Association of Surveyors and Engineers for 1880, I find the following :

"Again, the posts for lines closing on North or West boundary of township are often found to be off the boundary line, one side or the other. Query, as to whether the boundary should be deflected to pass through these posts, was definitely answered to the effect that the boundary lines are established before these closing posts are set, and are independent, that the closing posts, like sight trees, serve to determine the location of the section line, but that the latter terminates on the boundary."

The opinion as above expressed is also entertained by many other surveyors ; but the reasons for that opinion have never appeared satisfactory to my mind, and in the absence of any judicial determination of the question, for the purpose and in the hope of eliciting a full discussion of the subject, with the reasons for and against, I have written this communication, being a review of the arguments advanced in support of the above conclusion (so far as I have heard them) and also as a statement of the reasons for an opposite conclusion. But before entering on the discussion of the subject, that the reader may

get a clearer idea of the question and better comprehend the arguments advanced, I submit the accompanying diagram.



It is asserted, first, that the exterior boundary lines of a township having been run by a different surveyor or surveyors, and antedating the subdivision survey, is therefore entirely independent of and absolutely controls it.

This I hold to be an inadmissable assumption of facts and conclusions ; for in the surveys of the public lands when the double corners were required, especially the early surveys, many instances can be found in which the deputies' contract included the township and subdivision lines of the same lands ; and in some cases the standard parallels or correction lines, and even portions of the principal meridian, have formed a part of the contract. Now, I hold that the survey of the exterior boundary lines of a township and the interior subdivisions or section lines of the same township, though usually made by different surveyors and at different dates (yet not invariably, as I have shown), are but parts and parcels of one whole, entire survey of the township, required by the law to be made and fully completed before any of the township can be offered for sale. Each is made under and by authority of the same law, and when returned with the approval of the Surveyor General, is of equal binding force and validity, forming one entire and perfect survey of the township ; priority in date of execution giving no precedence in authority of the one over the other, but both being taken together and regarded in law as one survey—the survey of the township. If they are not to be regarded as a unity, and time or date of making of the surveys gives precedence of one over the other, it is surely the last survey that must be regarded as paramount ; as each is subject to resurvey, change, or modifica-

tion at any time before the government sells the land, and each has to be approved and returned by the Surveyor General before they are of any legal validity (and which approval and return is usually in the order of their execution). If then there should be found a conflict between the two surveys, the last survey may reasonably be considered as a change or modification of the first survey, so far as they disagree ; just as a subsequent legislative act is construed as modifying or repealing a former act in all matters wherein they conflict or are inconsistent.

It is further argued on the same side, that the subdivision surveyor was required by his instructions to close on the exterior boundary survey of the township, and that the corners not having been made in accordance with his instructions, may be disregarded, treated as void, and new corners made at the proper intersections ; that the only use of the old corners is to indicate the intersections, the points at which the new corners are to be made. Now it is not true that the subdivision surveyor was absolutely bound by the exterior township boundary, for if in closing upon it he should discover a material error, he was required first to retrace his own lines, and if the error was not there, then to retrace so much of the township boundary as was necessary to discover and to correct the same, even to the extent of making new lines and corners, destroying and obliterating the old ones, noting fully all the changes in his field notes. And further, does a neglect or disregard of instructions necessarily render void the corners or lines ? If it does, are there any of our section lines or corners that will stand the test of conformity to instructions ? Is it not a notorious fact that none of the old section lines are true meridians, that no three of government corners will exactly align, and no two half miles are of equal length, either in the exterior or subdivision of the township ? Does not every experienced surveyor know that the $\frac{1}{4}$ section corners on east and west section lines are frequently materially out of line with and not in equal distance from their proper section corners, in some instances being as much as 4 or 5 chains out of proper place, the lines frequently not having been run through and corners corrected into line and equal distance ? Does he not find sight or line trees not in right line with the corners on each side of them ? Yet in every case, if the surveyor is satisfied from the notes and all the evidence that they are the original government corners and line trees, he abides by and conforms his surveys to them, although the government surveyor violated his instructions in running the lines and making the corners as he did. And the courts sustain the validity of such original survey lines and corners, denying the right to correct or change the government surveys.

A further illustration of this is the case of town plats. Supposing A, being the owner of the W $\frac{1}{2}$ of the S W $\frac{1}{4}$ of section 4 and the E $\frac{1}{2}$ of the S E $\frac{1}{4}$ of section 5, as shown on the foregoing plat, desires to have these surveyed and laid out into town lots. On account of his familiarity with the general system of the government surveys

and local knowledge of the region, or other reasons, he employs B to survey the two tracts of land and establish their corners and boundaries; and after such survey, for reasons satisfactory to himself, he employs C to lay out and plat the town, giving him instructions to make the section line between the sections the line of a row of lots. C proceeds to make the survey of the town, and through carelessness, ignorance or wilfulness (if you please), drives the lot stakes not all on the line as instructed, but some on one side and some on the other side of it. He makes a plat of the town, on which plat the section line, in accordance with instructions, is shown to be the lot line, certifies to the survey and plat, and it is acknowledged by A and recorded in conformity with all the requirements of law as to town plats; A then sells the lots and they are built upon as staked off: afterwards it is discovered that these lot stakes (*i. e.* original monuments of survey) are not on the true section line as represented by the plat and notes. In such a case would there be a question which was to take precedence and control, the line instructed to be laid out and shown on the plat or the original stake monuments in the ground? I think every surveyor would say, and I am certain every court would decide, that the monuments must govern. From the foregoing may we not safely conclude that the mere fact of the instructions not having been conformed to in establishing the corners on the town boundary does not of itself make them void, and if they are void they must be so for some other cause.

It is also urged that private rights would be violated if the first or exterior boundary line survey is not maintained; that parties made their entries and acquired title and rights to that line on both sides, and according to that line and those rights cannot be disturbed. This is assuming for granted the very fact in controversy, viz.: that that line is the true boundary line, and then basing an argument upon that assumption. That kind of reasoning will apply with equal force for the changed line, assuming it to be a true line. I will dismiss this argument without further comment, and take up what I consider the real question at issue, and that is to be decided, viz.: which shall determine and control boundaries, whether clearly defined, undoubted tangible monuments, such as government mounds, marked stones, witness corners, &c., or intangible mathematical lines?

The tenor of all judicial decisions has been to give precedence to monuments over everything else, placing the weight of evidence of boundary in the order as follows: 1st, monuments; 2d, course and distance; 3d, area, &c. I think also it is a fair construction, if not the clear intent, of the act of Congress of 1805, to make the same distinctions when it declares: "that the boundaries and contents of the several sections, half sections and quarter sections of the public lands of the United States shall be ascertained in conformity with the following principle, any act or acts to the contrary notwithstanding: 1st, All the corners marked in the surveys returned shall be

established as the proper corners of sections or subdivision of sections which they were intended to designate. 2d, The boundary lines actually run and marked in the surveys returned shall be established as the proper boundary lines of the sections or subdivisions for which they were intended, and the lengths of such lines, as returned, shall be held and considered as the true length thereof, &c. 3d, Each section or subdivision of section, the contents whereof shall be returned, shall be held and considered as containing the exact quantity expressed in such returns, &c." So, too, the "Manual of Instructions for Surveyors General and Deputy Surveyors" of the public lands, issued from the department of the Commissioner of the General Land Office, seems to enforce the same idea of the pre-eminence of corners, using the following lauguage about corners and their perpetuation:

"To procure the faithful execution of this portion of a surveyor's duty is a matter of the utmost importance. After a true coursing and most exact measurements, the corner boundary is the *consumation* of the *work* for which all the previous pains and expenditures have been incurred. If, therefore, the corner boundary be not perpetuated in a permanent and workman-like manner, the great aim of the surveying service will not have been attained."

Now, with the light of these judicial rulings, the act of Congress, the interpretation of the Commissioner, and the mathematical fact that there can be no such things as proper corners of a section within or without the boundary lines of the section, the corners must designate the extremities of the sections, the intersections of the boundary lines and the sections must extend to the corners and can not go beyond them. Are we not, therefore, justified in concluding that the corners established by the government subdivision surveyor, in the language of the act of 1805, must be considered the "proper corners of the sections which they were intended to designate"; not witnesses to or markers showing the true corners to be somewhere else, but the proper, true, lawful and only corners of the sections. They being the true corners of the sections, then one of two consequences must necessarily follow: either the exterior boundary lines of the township as first surveyed must have been so modified by the subdivision survey as to conform to and pass through the subdivision corners, or else there will remain gore strips of land which have never been sold or have been twice sold by the government, according as the subdivision corners fall short of or extend past the exterior boundary lines; for if the line A C, (see diagram) is the true boundary line of the township, then it is also the true boundary line of sections 4 and 5, for their northern limits are fixed and determined by the township boundary; aud B, which by act of Congress is declared to be their corner, is located entirely within section 33 of another township, perhaps a rod or more distant from sections 4 and 5 —certainly a remarkably anomalous feature for even anomalous or fractional sections. And as a further consequence of this remarka-

ble state of affairs, Mr. Smith, the owner of the N. W. ¼ of section 4, and Mr. Jones, the owner of the N. E. ¼ of section 5, of which B is the lawful corner, have the legal right to go to, improve to, and protect the lawful corner of their land; and Mr. Brown, the owner of the S. W. ¼ of section 33, has the legal right to prevent their improving or going to their corner, to treat them as trespassers if they do, and even remove their corner from off his ground. But it is unnecessary to pursue this line of argument further, as no such conflicting and absurd consequences can exist; and if, as I have endeavored to show, the subdivision corners are the true lawful corners, then the exterior boundary line A C E G, as first run, must have been so changed and modified by the subdivision survey as to pass through the subdivision corners, and the deflected line A B C E F, (being straight lines from the subdivision corners to the nearest corners, line trees, or other monuments each side of them) on the original exterior boundary, becomes the true township boundary line.

But to return to the idea advanced by the Michigan Convention, that the antedating or priority of the date of a survey gives priority of right. This idea is derived from the land system, or rather want of system, in the old states, in which private surveys of irregular tracts of land, and registered claims according to survey, are regarded as the beginning or foundation of right and title to the land from the state. Thus A, making first survey and claim, can not be disturbed in his rights by subsequent survey and claim of B. In these cases each survey is a complete survey in itself, and independent of the other, and all other surveys. And hence it is that priority of the execution of a survey is an important consideration in such cases. But this state of facts is totally inapplicable to the U. S. land system. No private individual is allowed to employ a surveyor and make a survey of any tract of the government land (either irregular or regular) upon which to register a claim of title; but the government, by its own authorized agents, causes the whole land to be surveyed and laid off into regular sectional subdivisions, of uniform dimensions, which are located and numbered by fixed rule, and as previously stated (and I desire it should be steadily kept in mind) this is done by a *series* of *connected* and *dependent surveys,* neither of which is of itself a complete and independent survey of the land, but each constituting a necessary part going to make up the perfect system or *whole survey*. Thus, in the State of Illinois, what constitutes the system is the survey of the principal meridians, base lines, correction lines, range, town and section lines, the subdivisional section lines being the last in order, and the completion of the survey system. And in the sale of the public lands by the government, the unit measure of description is the section (the same as the acre is of contents or the mile is of length), to which all the sales and patents for the regularly surveyed lands strictly conform. Thus the sale and patents are for sections, ½ sections, ¼ sections, ½ ¼ sections and ¼ ¼ sections, always making the section the controlling unit in describing

the land. The section then being the final government subdivision survey of the public lands, and the controlling unit of description, and its sides of a mile square being also the unit measure of length, it does seem to me, therefore, to be but a fair presumption to conclude that the section corners are to receive equal consideration in determining its boundaries.

And even the act of 1805, which makes the corners and boundary lines, and the length thereof, as returned by the surveyor general, conclusive evidence of their being the proper corners and boundary lines, and the true length of such lines, by the express words, applies that rule of evidence only to the corners and boundaries of the sections and fractional parts thereof. The corners and lines constituting the town, range, correction, base and meridian lines, as such, are not therein enumerated, or any where so declared to be evidence, and are only affected by the provisions of the act in that particular in so far as they are composed or made up of the corners and boundary lines of the sections and parts of sections. Yet as each of their component parts is separately made conclusive evidence, I suppose that it would necessarily follow that the parts when combined as a whole in the survey system, would also be conclusive evidence. Thus it is evident, they get their binding authority, not from their preeminence as town, range, correction, base and meridian corners and boundaries, but from the fact that they are the corners and boundaries of the sections constituting those town, range, correction, base and meridian lines. So, instead of being above and superior to, they are subordinate and dependent upon the corners and boundaries of the sections for their legal status and significance.

And resuming again the consideration of the exterior boundaries of the township and the corners for the sections thereon, I presume it may be safely asserted as a matter of fact (though in conflict with the presumption of law), that the corners made on the township and range lines in sectionizing are, in but few instances, in the exact lines of those boundaries as established by the township surveyor; at least such has been my observation and the experience of others so far as I have been able to learn. That being a fact, then, according to the Michigan Convention theory, all these corners are to be disregarded and new corners made; that is, 5-17 of all the corners on the township and range lines are null and void; and of course the "consummation of the corner boundaries" (for which the Commissioner of the General Land Office is so earnest) "has proven a failure," and even the act of Congress which declares them to be the true corners has therein been defeated. Are the advocates of the Michigan theory prepared to assume the full consequences of their position, or will they take the ground, as some do, that it is only gross errors of alignment that should be set aside? Now, if the government corners can in any contingency be set aside for error of alignment, and new corners substituted for them, it must be for the error and not the extent of error. And, then, who is to determine that error exists and the

sufficient amount of error, against the presumption of law that there is no error; for we are continually reminded that if there is any discrepancy in line or measurement between the government surveys and our own, that the law presumes it to be our own error, and not in the government surveys, and that we must make our work conform to the government survey. Then is it for each private surveyor in every case as it arises in his practice to judicially determine that there is error and of sufficient amount to authorize his disregarding the clear and emphatic command of the law? Congress has conferred upon the Land Department the exclusive control of the land surveys, and while the land belongs to the government that department is empowered to correct all errors in the surveys; but after the land has been sold, the Surveyor General disclaims all authority and control over it. Now, does the act of sale which divests him of authority, immediately invest every private surveyor with power? If not, when and where has the private surveyor been clothed with the high judicial power, or is each case to be presented to the court for the judge to set aside the act of Congress? I am desirous of knowing the proper mode of procedure in the premises, and would like the advocates of this idea to enlighten me as to the manner in which surveys made in obedience to the law of Congress, by deputy surveyors authorized to make the survey by the law, approved by the Surveyor General appointed for that purpose under the law, returned by the Surveyor General as directed by the law, declared correct and conclusive as so returned by the law, and finally, in pursuance of the law, the lands sold in conformity with said survey and returns, can be set aside, over-ridden, and held for naught by every county or private surveyor. But if these subdivision section corners are void, and therefore can be disregarded, then it clearly follows that they cannot be used for the purpose of making other corners; because being void or null they are not evidence of any thing or for any thing. Neither can they be regarded as witness corners for the place of the assumed true corner, because they are expressly stated in the returns of the Surveyor General to be the section corners and are declared by the act of Congress to be the proper corners of the section. Nor are there any facts shown by the returns that would bear the most remote indication that they were ever intended for, or could possibly be used as witnesses, such, for instance, as are specified in the "Manual of Instruction" of 1855, page 11, or "Instructions from the office of Surveyor General of Illinois and Missouri," page 18. As witnesses, even those absolutely important requisites of bearing and distance are wholly wanting. Then it must conclusively follow that if they are not the true corners, neither are they witness corners, and cannot be regarded as aught else than nullities, and of course cannot be used for any purpose.

Again, it is claimed that the act of Congress of February 11, 1805, declares that the "boundary lines actually run and marked in the survey returned" as well as the corners returned, are to be held

and considered as true. While this is so, yet in a case of conflict between the corners and lines, the act does not, either expressly or impliedly, give precedence and authority to lines over corners, or in any manner conflict with the well established rulings of the courts as to monuments and lines; and as statutes are to be construed in conformity with the established rules of evidence unless a contrary intent be clearly expressed, and as by the rules of evidence they are ranked and take precedence in the exact order of their enumeration in the act of 1805, of course that order must govern, there being nothing either expressed or implied in the act to the contrary.

But the claim that is made for the supremacy of township surveyed lines over the subdivision section corners, makes it important to ascertain exactly what government surveyed lines are. My understanding of them is, that they are merely the compass and chain connections of the government corners or monuments; and having but one of the properties of extension, viz., length, are imperceptible to the senses, purely mental creations; and if anywhere apparent evidences of their existence are to be found, those evidences, upon assuming a real substantive form, cease to be lines, and at once take the higher character of monuments; they have not as much as the mark of the chain as it was dragged along the prairie grass, nor even the substance of a shadow, to designate their identity, and about all that can be said of them is that they are the surveyor's sights through the slots of the compass and the chainmen's "stick" "stuck" as they followed after him. Now it is these ideal lines together with the government monuments consisting of mounds, stones, posts, trees, &c., that constitute the township boundaries; and of these two elements of boundary it must be self-evident (without reference to the decisions of the courts) that corners are the important governing factors. The corners are what give form and fixed location to land; from and to which course and distance are run; and without which it would be difficult to find beginning, ending or location to land, or anything by which it could be identified; but from which, when established, course, distance and area, if omitted in the calls, can be accurately ascertained. And corners being the important governing factors and the higher evidence of boundary, must in any conflict between them be the controlling element. To give to the act of 1805 an interpretation that would make the lines control the monuments, would be to reverse every rule of legal construction that has been established and maintained by the courts for centuries. But in order to constitute lawful boundary lines as specified in the 2d clause of the 2d section of the act of 1805, there are three essentials necessary: 1st, that the lines should have been "actually run"; that is, actually compassed and chained, or coursed and measured. 2d, that the boundary lines should have been "actually marked", viz., corners actually established at certain required distances or at certain specially returned distances, on the compassed and chained lines, or as stated in the first section of the act, "by marking corners on said lines," or

in the language of the Manual of Instructions (as legalized by act of Congress in 1862) "consummating the corner boundaries." Now what is meant by the expression "actually marked" is explained by the 1st section of the act, in which the words *marked* or *marking* are used five times in the sense of making or establishing corner monuments; thus "by *marking* a corner on each of said lines," "by running straight lines from the mile corners thus *marked*," "by *marking* on each of said lines intermediate corners," the half mile corners heretofore *marked*," and "intermediate corners shall at the same time be *marked* on each of said dividing lines." Here the word "marked" is used as synonymous with made or established, and is applied to the corner monuments; and it must be the corner monuments to which the 3d clause of the 2d section refers, or else in prairie surveys it can have no application, as no other marks were made, or could have been made, for there was nothing to mark, and consequently, if the corner monuments are not the actual marks, then these boundary lines as returned, not having been marked, are not the "proper boundary lines of the sections or subdivisions for which they were intended." And 3d, that the boundary lines thus run, and the corners so marked, should have been *returned* by the surveyor general. The first two essentials are acts done by the deputy surveyors in the field, and their relative importance is forcibly stated in the foregoing extract from the Manual of Instructions, wherein they are described to be the consummation of the work for which all the previous pains and expenditures have been incurred, &c. And the last essential specified in the act, is but the clerical duty of making copies of the field notes and plats of the surveys and transmitting, or in the words of the act, *returning* them to the general and district land offices by the Surveyor General, with his approval of the same, Then even this 2d clause of the 2d section does not sustain the Michigan theory; for though taken disconnected from and independent of the 1st clause, it fails to prove that of the essentials of boundary, course, distance, and monuments, that course and distance are the most important, and that therefore the courses and distances of the original township surveyed lines must control the subdivision section corners; but on the contrary, if it proves anything, it goes far towards maintaining the opposite position, and, coupled with the 1st clause, to my mind it clearly establishes the principle that the corners must control and govern the lines.

So far in the discussion of this question, the conflict between the original exterior boundary lines of the township and the subdivisional section corners has alone been considered. There is yet another feature in the case that has not been alluded to; it is the conflict between the original exterior township boundary lines and the length of the subdivisional intersecting section lines. While the act of 1805 declares that the "boundary lines actually *run* and *marked* in the surveys *returned* shall be established as the proper boundary lines of the sections or subdivisions for which they were intended,"

it also declares that "the *lengths* of *such lines*, as *returned*, shall be *held* and *considered* as the *true length thereof*." Now if the subdivision section corners are changed, as required by this Michigan theory, it necessarily changes, and shortens or increases, the lengths of their subdivision connecting lines, and the lengths of these lines thus changed will cease to be the lengths returned by the Surveyor General, and consequently not the true lengths as declared by the act of Congress. Thus this theory, that the survey of the exterior boundary lines of a township is a separate and distinct act, of such high and paramount character as to necessarily subject all other lines and corners to them, leads to these obvious contradictions and conflicts in construing the different clauses of the act of 1805, while the opposite idea (of holding the exterior and interior lines and corners of the township to be but the parts of a system, which are to be combined and *taken together* as *one survey*, the *survey* of the *township*), will entirely avoid all conflict and harmonize the different provisions of the law.

And now in conclusion, the extent of this question, reaching as it does every government township survey in the whole northwestern territory, and extending even far beyond; and its importance, inasmuch as it affects in many instances very valuable property, in cases where these lines fall within or are in the immediate vicinity of cities or villages, as also in cases where expensive permanent improvements have been made to them; and the fact that there are no direct decisions of the question by the courts, and but little information to be obtained from the bar, thus leaving each surveyor to act upon his own interpretation of the law, or what he thought the law should be, resulting, and likely to continue to result, in great conflicts in the private surveys of those lines, that must ultimately produce serious troubles, which could and should be prevented by an early settlement of the question, is my apology for bringing the subject before the public.

Hoping that this article may be the means of drawing out a full and fair discussion of the question, and of throwing more light upon a long mooted subject, and its ultimate adjudication and final settlement, it is respectfully submitted to the consideration and criticisms of both the professions of the law and surveying.

AUTHORITIES SUSTAINING MY POSITION.

Bouvier's Law Dictionary.

Boundary. Any separation, natural or artificial, which marks the confines or lines of two contiguous estates.—3 Toullier, N. 171.

The term is applied to include the objects placed or existing at the angles of the bounding lines, as well as those which extend along the lines of separation. A natural boundary is a natural object re-

maining where it was placed by nature. A river or stream is a natural boundary, and the center of the stream is the line.—12 Johnson's N. Y., 252.

An artificial boundary is one erected by man. The ownership in the case of such boundaries must of course turn mainly upon circumstances peculiar to each case.—5 Taunt., 20, 3 id., 138 Barnw., &c., 251.

Boundaries are frequently denoted by monuments fixed at the angles. In such case the connecting lines are always presumed to be straight unless described to be otherwise.—16 Pick. Mass., 235; 6 T. B. Monr. Ky., 179; 3 Ohio, 382; 1 McLane C. C., 519; 2 Washburn Real Prop., 632.

Monuments. Permanent landmarks established for the purpose of indicating boundaries.

2. Monuments may be either natural or artificial objects; as rivers, known streams, springs, or marked trees.—6 Wheat., 582. EVEN POSTS SET UP AT THE CORNERS.—5 Ohio, 534—and *control the call for course and distance and establish the boundary.*

3. When monuments are established they *must govern*, although neither course nor distance nor computed contents correspond.—6 Wheat., 582, &c.

Fixed boundaries, such as marked trees, must prevail over course and distance when they differ.—14 Penn. State Rep., 59.

Where, as in a patent from the United States, the land is only described in the conveyance by numbers and quarters, the court will look at the plat and field notes of the public surveys, in order to locate the land, and these are considered as part of the patent itself. *Field notes must* YIELD TO ACTUAL MONUMENTS *erected by the original surveyor*, and are only to be relied on as evidence to assist in ascertaining the exact situation of the monuments.—McClintock vs. Rogers, 11 Ill., 279.

It has been repeatedly decided by this court, that the artificial or natural boundries described in a grant or deed of land, though varient from the distances or courses called for, nevertheless constitute, if sufficiently identified, the true boundaries of the tract.—1 Marshall, Ky., 96.

In ascertaining the boundaries of surveys and patents the universal rule is this: That whenever natural or permanent objects are embraced in the calls of either, these have ABSOLUTE CONTROL, and both *course and distance must yield to them.*—Brown vs. Huger, 21 Howard U. S., 305.

Both course and distance must give way to natural or artificial monuments or objects; and course must be VARIED and DISTANCE LENGTHENED or shortened so as to conform to the natural or as-

certained objects or bounds called for, &c.—Buckner vs. Lawrence, 1 Doug. Mich., 19.

The law says that the land is conveyed around which the surveyor actually ran the lines and *fixed his monuments. Monuments, tangible things* capable of being identified by witnesses, *must always control and supersede* course and distances, which are more liable to be set down in error.—25 Ill. Reports, 163.

The corners established by the original surveyors of public land under authority of the United States, are *conclusive as to boundaries of sections* and divisions thereof, and *no error in placing them can be* CORRECTED by any survey made by individual or by state surveyor.—Climer vs. Wallace, 28 Mo., 556.

Area yields to course and distance, and course and distance yield to monuments.—Cottingham vs. Parr, 93 Ill., page 233.

A mistake in a surveyor's certificate, attempting to give a description of the land actually surveyed and platted into town lots describing the town as being on a different quarter of the proper section, does not render the survey and subdivision of the property into lots and blocks uncertain, and for that reason void, when the *monuments* planted by the surveyor at the time of the survey, fix the boundaries of the survey definitely and certainly. It is well settled law that monuments established by a surveyor at the time of making the survey will always prevail over written descriptions when a contradiction exists.—People of the State of Illinois vs. F. Stahl, 101 Ill. Rep., page 346.

Should you find a manifest error in measurement of any township line, within or bounding your district, you are to correct such error by remeasuring such township line from where the error is found to the north or west end thereof, the section and quarter-section corners thereon are to be removed to the proper distances and there established, &c.—General Instructions of U. S. Surveyor General for States of Ohio, Indiana and Michigan, 1850, page 27, sec. 14; Illinois and Missouri, 1850, page 24, secs. 25 and 26; Instructions to Surveyors General, by Commissioner of General Land Office, 1855, pages 21 and 22.

BRIDGES.

By A. C. BRAUCHER, of Lincoln.

In presenting the subject of *Bridges* for your consideration and discussion this afternoon, a due appreciation of its magnitude causes me to touch upon the fundamental processes only, leaving the finer points to be developed by each to his fancy. The steps necessary in the building of a bridge are numerous and important, and failure in the proper execution of any one tends to the ultimate destruction of the whole, and ofttimes furnishes "Death and Disaster" as the head-line for the half-column report of the metropolitan press, which contains the names of the wounded, dead and dying, together with a description of the unknown.

The work of building a bridge will usually be taken up in about the following order :

(a.) Conception and execution of the design.

(b.) Calculation of the stresses, or outer forces, to which the structure will be subjected.

(c.) Calculation of the maximum and minimum strains, or inner forces, due to the action of the outer forces.

(d.) Selection and proper testing of materials.

(e.) Designing cross-sections and computation of area required.

(f.) Drawing of details.

(g.) The mechanical work of getting out the parts.

(h.) The erection of the structure.

Your attention will be more particularly called to the combinations of forces which produce maximum and minimum strains in the various pieces, together with the manner of their action and the method of their computation. These forces will include in a vertical plane the following: (a.) Dead load, or weight of bridge ; (b.) live load, or weight of moving train ; (c.) the engine excess ; (d.) the snow load ; (e.) the excess of weight thrown upon the leeward truss by the action of the wind upon the moving train ; (f.) the reaction of the abutments. In the horizontal plane the forces are the wind on bridge and wind on train, which must be resisted by the horizontal truss and portal bracing. Let us now see what combinations of these forces will produce the maximum and minimum strains in the various members.

For the upper chord we have the greatest strain (compression) under the action of full live, dead and snow loads, with wind from windward. (This is strictly true only when the compression in the upper chord due to wind from windward exceeds that due to additional weight thrown upon the truss by the action of wind from leeward ;

otherwise wind from leeward will give maximum.) The least strain will occur when we have merely the weight of the bridge with wind from leeward.

In the lower chord the maximum tension occurs under the action of full live, dead and snow loads, with wind from leeward ; the minimum under weight of bridge with wind from windward. The flange strains are greatest at the center of the span, and diminish each way toward the abutments.

A brace or web-member in any bay undergoes a maximum strain when the live load extends from that bay to the further abutment, with wind from leeward and total dead and snow loads acting. The same brace will undergo a minimum strain (or maximum of the opposite character) when the weight of bridge acts with live load from that bay to nearer abutment and wind from leeward. The strains in the braces are greatest near the abutments and diminish toward the middle of the span.

The maximum strain in any wind brace is that due to dead wind load and live load from that bay to the further abutment—the minimum being zero when the loads are not acting.

Having thus computed the maximum and minimum strains in all the parts, we now proceed to the determination of dimensions of members, due allowance being made for vibration and impact, since the effect of a load suddenly applied is twice as great as when placed on by degrees, while under the most favorable circumstances the vibrations caused by the timely repetition of a comparatively slight force may become very dangerous to the most substantial structures of suspension. You have doubtless all heard and possibly laughed incredulously at the story of the violinist who sat at the end of a long bridge and fiddled until the bridge fell down ; and also of the farmer who crossed safely with a team and heavy load a bridge which afterwards went down when his dog came trotting along behind. I believe the first story, for it doubtless refers to the bridge of the violin which fell, and any violinist could fiddle until the bridge fell down. Of the truth of the second story, though more reasonable on the face of it, I have my doubts.

But the force which these stories pretend to illustrate really exists and depends for its power upon what may be called "storage of energy." As an illustration, I will quote some data from an experiment made last week, in which I deflected a 2″x10″ oak plank over an inch and a half by means of a pressure insufficient to break a common match. The experiment was as follows : A 2″x10″ oak plank twelve feet long was placed upon supports about eleven feet apart. At the middle point was placed an anvil and other weight, say two hundred pounds, causing a deflection of an inch and a quarter. Now, a pressure was alternately applied to and removed from the face of the anvil by means of a common match, which pressure could at no time have exceeded five or six pounds. In this manner, by repeated application of the pressure at the proper time, a

further deflection of an inch and five-eighths was produced, causing a vibration the amplitude of which was about three inches. This effect could have been produced by a single force of no less than five or six hundred pounds, and yet was the stored energy due to a repeated pressure of but five pounds. If the plank were perfectly elastic, there would be no limit to the amount of energy which could thus be stored, for the effect of the first impulse would be taken up by or stored in the elastic resistance of the plank to flexure ; when the pressure is removed, the plank would rebound to a little beyond its former position, thus storing the energy of the first impulse in the weight. This in turn is again restored to the fibres of the plank along with the energy of the second impulse, thus producing an increased deflection. In this manner an unlimited amount of energy could be added to and kept vibrating between the plank and the weight, until at last the strongest material would give way.

Let us now turn our attention to the determination of the strains or inner forces. Since a bridge is a structure of stability and all outer forces must be transmitted to and resisted by the abutments without motion of rotation or translation, we may base our operations upon the following fundamental conditions:

1st.—The outer forces must constitute a system in equilibrium, both as to rotation and translation.

2nd.—If the truss be cut by a plane in any direction, the stresses acting upon either portion must be held in equilibrium by the strains in the cut pieces.

3rd.—The forces acting at any joint or apex must be in equilibrium.

These conditions give rise to two general methods of solution—the method of moments and the method by resolution of forces, each of which may be treated either algebraically or graphically.

By resolution of forces, we form two equations,

Summation of X Forces = 0, and Summation of Y = 0,

between the forces acting at any apex, from which we may find two unknown quantities, or the strains in two pieces. Hence, if at any apex the strains in more than two pieces are unknown and cannot be determined in some other way, the truss becomes indeterminate, unless an equation for each additional piece may be deduced from other relations. It is better, however, to change the design of the truss at this point so as to remove such superfluous and indeterminate pieces.

By the method of moments we eliminate the effect of the strain in two cut pieces by taking the origin of moments at their intersection. Then forming the equation,

Summation of moments = 0,

the strain in the third piece may be found. The reaction of the abutment may be determined from the equation,

$$R = \frac{\text{Summation of P Forces x a}}{l}, \text{ which becomes}$$

$$R = \frac{\text{Summation of P Forces}}{2}$$

for symmetrical loading, in which R is the reaction of the abutment, P any weight or load, a its distance from the opposite abutment and l the length of span.

The following observations upon a bridge truss with parallel flanges may be of interest.

1st.—The strain in the first brace is equal to the reaction of the abutment multiplied by the secant of the angle of inclination to the vertical. For the first flange we have reaction of abutment multiplied by the tangent of the angle the first brace makes with vertical. In general, the strain in any flange is equal to that of the adjoining flange plus the horizontal components of the strains in the two braces which meet in the apex between the two bays. It is also equal to the summation of moments of the outer forces for that bay divided by the depth of truss.

2nd.—The strain in any brace is found by multiplying the shear at that point by the secant of the angle of inclination with the vertical.

3rd.—The pair of braces meeting at any unloaded apex are equally strained.

4th.—The reaction of either abutment for any part of the dead load, or live load, is proportional to the distance from the opposite abutment.

5th.—For symmetrical loads the strain upon the central pair of braces is zero for an even number of loads and $\frac{1}{2}$ P times secant of vertical angle for an odd number of loads.

6th.—Those braces will need counter-bracing in which the strain due to the dead load is less in amount and of opposite character to that produced by the live load.

Let us now determine the effect of a uniformly distributed moving load from the time it starts across the bridge until it covers the entire span. Let AB (fig. 1) be the span, with load crossing from B to A.

Let x=distance from A to head of approaching load.

l—x=length of load.

a=distance from A to any point at which the moments or shear are to be considered.

w=load per foot of span.

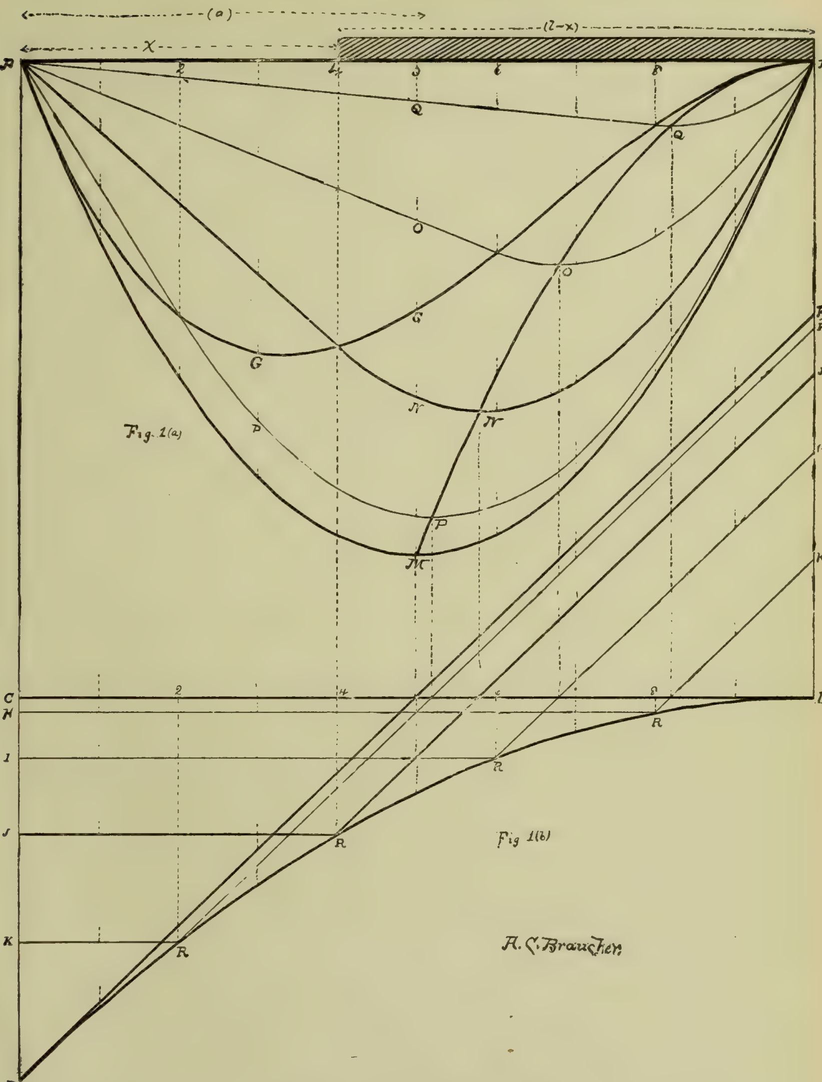
l=length of span.

R=reaction at A.

Then by moments we have

$$R\,l = w\,(l-x).\frac{l-x}{2} \quad \text{or } R = \frac{w\,(l-x)^2}{2\,l} \qquad (1)$$

From this we get the general equations for moments and shear at any point a:



$$\text{Moment} = \frac{\text{w a } (\text{l}-\text{x})^2}{2\text{ l}} - \frac{\text{w } (\text{a}-\text{x})}{2} \qquad (2)$$

$$\text{Shear} = \frac{\text{w } (\text{l x})^2}{2\text{ l}} - \text{w } (\text{a}-\text{x}) \qquad (3)$$

in which the second term disappears for $a < x$ by reason of w being zero for that part of the span. For any given value of x, the mo-

ments at any point a will be given by ordinates to a curve for $a > x$, and by ordinates to a right line for $a < x$. The shear will be given by ordinates to right lines in either case. Thus, for $x = .8l$, $.6l$, $.4l$, $.2l$ and 0, successively, in equation (2), we have the curves AQB, AOB, ANB, APB and AMB, respectively, from which we see at once that the moment at any point is greatest when $x = 0$. For this value of x in (2) we have the equation of maximum moments (curve AMB) as follows:

$$M_{max.} = \frac{wa(l-a)}{2}. \qquad (4)$$

The shear lines for $x = .8l$, $.6l$, $.4l$, $.2l$ and 0, successively, in equation (3) are HRH, IRI, JRJ, KRK and EF (fig. 1, b) respectively, from which we see at once that the shear at any point is greatest when $x = a$ and is zero when $x = \sqrt{2al - l^2}$. If we make $x = a$ in equations (2) and (3) we will have the equation of moment at head of load and equation of shear (maximum) at head of load, which are the equations of the curves AGB (fig. 1 a) and ERD (fig. 1 b) respectively.

$$\text{Moment} = \frac{w\,a\,(l-a)^2}{2l}. \qquad (5)$$

$$\text{Shear} = \frac{w\,(l-a)^2}{2l}. \qquad (6)$$

The equation of the points of maximum moments for any value of x is $\frac{l^2 + x^2}{2l} = a$ or $x = \sqrt{2al - l^2}$. This value of x substituted in (2) will give the equation of the curve MNOQB, or curve of moments at point of maximum during the progress of the load across the bridge. From this we see at once that the moment at point of maximum is greatest at the center of the span, or when $a = \frac{1}{2}l$. This value of a in $x = \sqrt{2al - l^2}$ gives $x = 0$; or, when the load covers the entire span the moment is greatest at the middle point. It may also be noted that the value of a which gives a maximum moment for any value of x will reduce equation (3) to zero.

The following facts may be briefly mentioned:

The shear at the middle point of the span is the same for the head of the load symmetrical in regard to the center; that is, for $a = \frac{1}{2}l$ and $x = \frac{1}{2}l \pm c$ in equation (3).

The curve ERD is a parabola, vertex at D and tangent to the lines CD and EF. The curve AMB is a parabola, vertex at M. The curve MNOQB is a parabola, vertex at B.

The moment at any point, for any position of the load, is equal to the area on either side of a vertical through the point included by the shear axis, C D, and the shear line for that position of the load. If this area is partly above and partly below the shear axis, one portion is to be subtracted from the other.

From this it follows that the shear axis always divides equally the area included between it and the shear line. A study of the figure will develop many other facts which time forbids to mention.

Let us now investigate the moment and shear produced by the locomotive excess, which we will treat as two equal, concentrated loads rolling across the bridge at a constant distance apart. Let A B (fig. 2) be the span, with the concentrated loads (P and P) crossing from B. to A.

Let x = distance from A to first approaching load.
" a = distance of loads apart.
" l—x—a = distance from B to second load.
l = length of span.
P = weight of load.
R = reaction of the abutment at A.

It will be necessary to consider the shear and moments at the point at which the first load is concentrated only, since we will have all possible combinations by so doing, as the second load may be considered as the first coming from the opposite direction. The reaction of the abutment is given by the equation

$$R = \frac{P\,(l-x)}{l} + \frac{P\,(l-x-a)}{l} \qquad (7)$$

in which the first term of the second member is the reaction due to the first load and the second term that due to second load. This is also the equation of maximum shear, at point of first load. For the equation of moments we have

$$M = \frac{P\,x\,(l-x)}{l} + \frac{P\,x\,(l-x-a)}{l} \qquad (8)$$

The equation of moments due to the first engine is

$$M = \frac{P\,x\,(l-x)}{l} \qquad (9)$$

and that due to second engine at point of first is

$$M = \frac{P\,x\,(l-x-a)}{l} \qquad (10)$$

Equation (9) gives the parabola AMB, the ordinates to which are equal to the maximum moment at any point due to a single load. Equation [10] is the parabola [AK6] of additional ordinates, which added to the ordinates of AMB give the curve of maximum moments under first load, ANYRB. In like manner 4HB is the parabola of additional moments under second load due to action of first load, and the curve AJSOQB is the curve of maximum moments under the second load.

If from any point on the parabola A M B lines be drawn to A and B, ordinates to these lines will give the moment at any point due to a load at the point from which the lines were drawn. In this manner the combined moments of any number of equal loads in any

position upon the span may at once be determined from the figure for any point desired.

The polygon of moments for the first load is A S B; for the second load, A R B; and for the combined moments we have the polygon A N Q B.

A study of the figure will develop the following facts, which it may be interesting to state briefly:

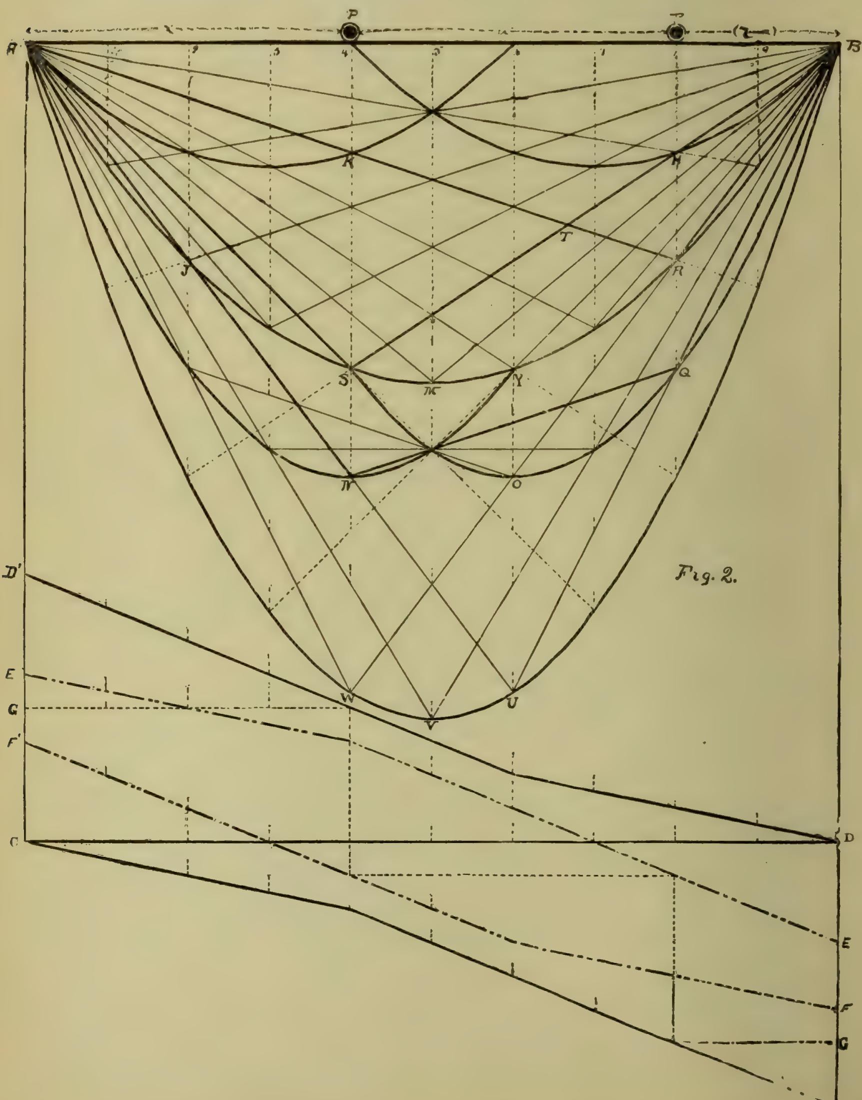


Fig. 2.

The maximum bending moment at any point is obtained by placing one engine at that point and the other between that point and the remoter abutment.

The moment at the center point is constant from the time the first load passes until the second load reaches that point.

The sides of the moment polygon A N and B Q produced will intersect at the point U, upon the parabola A V B, which is the curve of maximum moments due to two moving loads concentrated at the same point. Hence, if the two engines or loads be concentrated at the same point, they may recede from each other at a uniform rate without changing the moment at any point between the engine and abutment until one of the engines reaches the abutment.

A single load at any point will cause the same moment at that point as two loads concentrated at a point midway between the first load and either abutment.

Two loads concentrated at a single point will produce the same moment at two other points, where single loads are located, when the double load is midwav between the single loads.

The point at which a single load must be placed to produce a given moment at a given point may be found by drawing a line from either abutment through the end of the ordinate representing the given moment till it intersects the curve A M B, which intersection will give the required point. Hence there will be two such points, one on each side of the given point. Likewise, the point at which moment of two loads is equal is found by drawing lines from either load to the abutment beyond the other load ; the intersection of these lines will give the required point and will always fall between the given loads.

The line D D′ is the shear line for a point just in front of the first engine and gives a maximum positive shear.

The line F F′ gives the shear just behind the first engine. The line E E′ gives the shear just in front of the second engine and the line C C′ just behind the second engine, which gives a maximum negative shear. The dotted line G G is the shear line for the position of the loads as shown in the figure.

In conclusion, I desire to ask an explanation of a fact which does not exactly agree with mathematical principles to all appearances. It is this : The first differental coefficient of the equation [8] of moments should be equal to the equation [7] of shear ; but in this case we have from [8]

$$\frac{dM}{dx} = \frac{P\,[l-2x]}{l} + \frac{P\,[l-2\,x-a]}{l} \qquad [11]$$

while the equation for shear is

$$\text{Shear} = \frac{P\,[l-x]}{l} + \frac{P[l-x-a]}{l} \qquad [12]$$

Placin g[11] and [12] equal to 0, we have $x=\frac{1}{2}l-\frac{1}{4}a$ and $x=l-\frac{1}{2}a$. What is the cause of this disagreement with mathematical principles?

PILE FOUNDATIONS.

By F. J. SAGER, of Columbus, Ohio.

One of the most celebrated civil engineers in this country once said to me "if you are not very well informed upon any subject, undertake to write a paper upon that subject and you will learn something." This practice will develop in the investigating mind that follows it the whole theory of self-instruction. In attempting to write a paper upon *pile foundations* we hope to increase our own knowledge and are fully aware that a large field will be left uninvestigated when we have finished these remarks. The general subject of pile foundations we shall review in a very brief way, our special feature being the use of cast and wrought iron and steel in building bridge foundations, trestles, viaducts, and docks.

In geology there is said to be seven ages through which the world has passed; we hear of the age of mammals, etc. This illustration has also been figuratively applied to the arts and sciences, and we hear of the stone age, the golden age, etc. In this wonderful nineteenth century these terms are no longer applicable to represent the world's progress, at least in the sense of years or ages that they convey; for the world has and is making great and rapid strides in the mechanical arts and sciences, and the illustration can be applied only to represent the change from one series to another and not in the sense of time. We may say that we are rapidly passing from the age of animal power to that of steam and electricity. In the science and art of building we are passing out of the wood and stone age into the age of iron and steel.

The record of building bridge superstructures in the last twenty-five years will bear witness to this fact, and in that part of a bridge structure iron and steel are rapidly taking the place of wood and stone. We predict that this will also be true in foundation work for bridges, trestles, viaducts, docks, and piers. The age of wood and stone will be succeeded by that of iron and steel. Our experience for the present may be limited and the best plans undeveloped, but the great will power of the American engineer will find a way and will solve the problem.

In this great age of progress he who is liberal in his views, he who is willing to investigate, he who submits gracefully to have some of his pet theories exploded and shattered to atoms, he who is not "married to his idols", is a wise man. Science will overcome superstition. The inventor of the telephone no doubt would have been hanged for a witch in the early days of Boston and time of Cotton

Mather. What engineer of fifty years ago, when canals where the great highways of the United States, who prided himself upon his proficiency in all details of canal work, would have believed that he with all his canal education would be left behind in the great field of railroad engineering? In Ohio we have been having a careful geological survey made, maps, profiles, and cross sections, showing us the composition of the earth for hundreds of feet in depth; but what geologist would have gone into the low, flat lands of northwestern Ohio to find productive oil wells and such wonderful gas wells as have recently been discovered there? Hence in this age of strange things he that is liberal and is willing to investigate impartially the new methods, new appliances, and new theories, is a wise man.

Returning to the subject of pile foundations, we find that wood piles for supporting superstructures and for various other purposes have been used in many countries for years. Various methods of sinking them and many strange facts in regard to their supporting power have been discovered. The method most used in this country is with the cast iron drop hammer. The hammer is raised by various kinds of mechanical devices. It is then let fall upon the head of the pile, and the operation is repeated until the pile is driven to a sufficient depth. When the pile driver can be mounted upon a car or boat the motive power to raise the hammer is generally steam ; otherwise horse power is used. These hammers vary greatly in weight but usually range from 800 lbs. to 3000 lbs. They should never be of less weight than the pile to be driven. The ordinary steam hammer such as I have observed will strike when working well from 6 to 10 blows per minute, while the horse power hammer requires from one to three minutes for each blow. The gun powder pile driver is a successful machine. The gunpowder is exploded between the pile and hammer exerting its force upon the pile, thereby driving it down. It is said to make 30 to 40 blows per minute and that a pound of powder will sink a pile into mud 20 feet. Prussian engineers, it is said, have also driven piles by exploding dynamite on the top of them, the tops of the piles being protected by a thick iron plate. The well known tendency of dynamite to exert its force downward we think might be utilized.

The water-jet system is also a very important method and has been very successfully operated and in quicksand bottoms is very successful. The method is to apply a jet of water (through a small tube) to the bottom of the pile, allowing the pile to settle as the sand is displaced by the force of the water. In Mobile Bay hundreds of piles were sunk in this way with an ordinary steam fire engine. In some places water from city water-works has been used for this purpose. Piles may be sunk in this way very rapidly—in some cases a pile has been sunk 20 feet in less than a minute.

The Chinese are said to drive piles by first loading them down and then by the united strength of several men raising a wooden ram which they drop upon the head of the pile.

Bearing piles (by this we mean piles intended to sustain weight) when they do not rest on solid bottom are sustained by the friction against their sides in displacing the material about them. Their supporting power must therefore depend upon the character of the earth through which they are driven. It would therefore seem that our only method to determine their supporting power would be to compute the force used in driving them, but this method is also very liable to be in error. By actual test it has been found that frequently piles driven into the mud and quick-sand sinking two feet at each blow of the hammer, when left to stand for a few hours, could hardly be started by hammering them. This was no doubt due to the sand becoming settled and fixed about them. It also sometimes happens that in certain kinds of soil the piles although firm at first will gradually become loose and settle. In driving piles of wood in Mobile river where very long timber piles were used with one end larger than the other, the piles having considerable taper, it was found that if the small end was driven downwards the pile would gradually rise, conveying everything up with it. The piles were then driven with the large end down and no farther trouble was had with them.

Therefore no rule for the sustaining power of piles can be correctly applied for all conditions and under all circumstances. Yet we have formulated a rule by which the sustaining power of a pile may be determined. Using the velocity and weight of the hammer as factors by which we would determine the friction and consequently the supporting power of the pile, we think the following is a fair average rule to be applied in a majority of places. The rule is :

The extreme load in tons equals the cube root of the fall in feet multiplied by one-fortieth of the weight of the hammer in pounds and divided by the sinking in inches plus one.

Example.—Fall 16 ft., hammer 1,000 lbs., sinking $\frac{1}{2}$ in.;

$$\text{Extreme load in tons} = \frac{\dfrac{(16)^{\frac{1}{3}} \times 1{,}000}{40}}{\frac{1}{2}+1} = 42 \text{ tons.}$$

This should then be divided by a factor of safety of from 2 to 5 according to circumstances. These figures only carry us to the surface of the ground, and where piles extend above ground the part above the surface must be figured by different rules.

In designing a substructure for a bridge we must first examine the superstructure. Having determined the length and capacity of this, we have principally two unknown quantities, tention and compression, to which its members are subject. In an ordinary iron bridge the upper horizontal, and vertical intermediate and inclined end posts of the truss are compression members, while the lower horizontal and diagonal members are tension members. The materials used for them have been so thoroughly tested that certain uniform properties have become universal to them.

Having decided upon the strength and weight of the materials to be used and having determined the capacity or load the structure is to carry by rules well established, you have the entire weight to be supported by the foundation. The supporting power of the piles has already been determined up to the surface of the ground. That part of your substructure from the ground up to where it is to receive the weight of the superstructure will be subject principally to compressive forces, and aside from the stay-bracing may be computed by the simple rule applied to any post or strut. We prefer as a fair rule for that part out of the ground to treat it as a strut with one pin and one square-end bearing.

Our experience in building iron foundations is confined chiefly to the iron pile foundations patented by Messrs. Gray & Abbott, of Bloomington, Ill., a number of which we have designed and erected during the past year. As two substructures are rarely ever exactly alike, we will confine our remarks to those constructions common to most substructures. The piles consist of a hollow cast iron cylinder with radiated flanges as shown in the cut, the hollow cylinder being filled with asphaltum or cement.

About 10 inches of the top of the pile terminates in a full cylinder from 8 to 10 inches in diameter, while the lower part terminates in a solid point. These piles have been successfully cast and driven 33 feet in length. The upper end is furnished with a cap having a plate on top, and where greater length is desired the piles are spliced by means of sockets securing the ends. In this way we recently erected a structure 70 feet high. In places where the friction is not considered sufficient to sustain the weight the pile is to receive, a cast iron plate is made as large as desired and bedded below the frost, and the pile is then driven through and made fast to this plate so that the supporting power may be extended over a large surface. Where a great weight is to be sustained, the piles are driven in groups and are braced and connected with wrought iron rods, channels, I-beams, &c., after the plan of the ordinary iron trellis. Cast iron is used in making the piles because it is one of the best known materials to withstand compression (which is the principal force in your substructure), because it does not rust, corrode, or scale off when in contact with water or damp air, as wrought iron is sure to do. When driven in the ground and used as a substructure it is not subject to the same shock and vibration as if used in the superstructure and therefore is not so liable to break from that cause. In driving, also, such piles are subject to the severest test. We have seen a 2000 lb. hammer fall 18 to 20 feet on top of a cast iron pile where it was not driven more than one-half an inch at each blow. A small piece of plank is placed on the top of the pile so that the hammer and pile do not come in contact with each other. We were fully satisfied that these blows were sufficient test and that if the piles sustained the blow they would sustain any shock they were liable to receive when the structure was completed.

The cost of these foundations is of course largely in excess of that of the wooden pile, but is much less than first-class masonry.

This work has been used very successfully for railroad bridges and trestles, highway bridges, towers, hoists, and will be found very useful for viaducts, docks, &c. It is impossible in a limited space to give a complete description of this kind of substructures. Pamphlets containing further descriptions can be had by addressing *The Iron Substructure Co., of Columbus, Ohio.*

DISCUSSION.

Prof. Talbot—What is the price of iron piles per lineal foot?

Mr. Sager—They weigh 60 pounds per foot and as they are sold by the pound, the price would depend upon the price of iron. They are made of cast iron, and in driving we do not allow the hammer to come in contact with the head of the pile, but place a block of wood upon it while driving.

Mr. Bullard—Is there any trouble from ice?

Mr. Sager—The lower part is made solid. Where the pile is hollow and any danger is anticipated, it is filled.

Mr. Braucher—Is it often found necessary to use the bearing plates?

Mr. Sager—No. In almost all cases the friction of the mud sustains the pile. I would say that when it is intended to use iron piles a careful survey should be made of the locality where they are to be used, and the proper necessary length of the piles determined before manufacture.

THE HIGHEST ATTAINMENT IN DRAINAGE.

By E. D. SHREVE, of Bucyrus, Ohio.

[Mr. Shreve's manuscript on the above subject was lost in the mail before the February meeting took place. He spoke at that time from hastily prepared notes, and expected to re-write the paper for publication if the former one was not found. Owing to his absence from home, the Secretary has had great difficulty in communicating with him. The paper was both interesting and valuable, and it is to be regretted that this report must go to press without it.

The following brief synopsis of the paper is presented :

The speaker dwelt upon the importance of deep channels for main outlets for tile drains ; discussed the size of the main open ditch ; explained the best form of side slopes, and the way to obtain and maintain them ; called attention to the importance of rapidity in construction of the main drainage canals. He also discussed the question of the proper size of tile and the inter-adjustment of grades in tile drains.]

DISCUSSION.

Mr. Miller—I think that in the instance given by Mr. Shreve where there is a change from steep grade to flat, the tile on the flat grade would fill with sediment. Would it not be better to distribute the fall more evenly?

Mr. Shreve—The size of tile used on the different grades must be arranged with reference to the grade so that all parts of the line will, at certain times, be equally full and so flush the pipes.

Mr. Braucher—Will not water be forced out of the drain upon the land when the tile upon the flat grade is overcharged?

Mr. Shreve—When the ground is filled with water about the tile, it will be forced through. Tile should be proportioned so as to run full in all parts of the line.

Mr. Kyle—I think we need have no apprehension that flooding will take place in such cases.

Mr. Stanford—I have a case on my own farm in which I connected too much tile to an outlet main which ran through low land, and have injured this low land by so doing. It necessitates the use

of a line of larger main tile which I shall soon put in, in order to make the land tillable.

Mr. Hodgman—Is the velocity of the water the same in the flat parts of the drain as in those with greater fall?

Mr. Shreve—Certainly not.

Mr. Braucher—Could any water run into the tile from the land if it were completely filled?

Mr. Shreve—Not unless the pressure from without should be greater than that within. However, it runs full only a short time.

Mr. Ela—I have seen tile entirely washed out of the ground on low land where the tile was too small to carry the water required of it. In regard to the question as to where it is practicable to use a steam dredge, I think the area of the territory should be taken into account, the whole field must be examined carefully, and the means adapted to the surface and also to the subsoil.

Mr. Stanford—I will mention some of the drainage districts with which I am acquainted. The Vermilion Special District comprises an area of about 48,000 acres and lies at the headwaters of the Vermilion river. The ditch is now being made by a Chicago dredge. The Pella district comprises 5,000 acres and has 12 or 13 miles of ditches. One near Piper City has 9 miles of ditches. The Ashkum and Danforth Union District has 29 miles of ditches. The surface in these districts is flat, and the fall of the ditches is very slight, especially of those flowing into the Vermilion river. The upper nine miles of the river has a fall of only nine inches per mile, the slope of the banks being about 4 to 1. The land produces well some years, and a large part of it is cultivated, but any excess of rain floods the country and ruins a large part of the crops. The ditches must be shallow because of the shallow outlets.

Mr. Jones.—We have discovered that the slope of the banks is controlled by the fall of the streams. In the vicinity of Green River, we have not depth enough for our ditches to make the work complete, but have succeeded in reclaiming about 4½ acres out of 10 acres. We expect to improve the river and then we can secure better results. We expect to shorten the Edwards River, or make a cut so that the run will be reduced from 82 miles to 23 miles, and so obtain more fall. The greatest obstacle we have to contend with is the unwillingness of the people to consent to do thorough work. I would like to ask a question of the engineers present. In loamy soil, how great an angle can we make in the course of a ditch with fall of 6 to 7 feet

in 4 miles, 30 feet wide at base, sides with slope of 2 to 1 and depth ranging from 5 feet to 9 feet?

Mr. Shreve.—I should use a curve of about 8 degrees (700 feet radius.)

Mr. Ela.—Make the ditch big enough and let nature form the slope.

Mr. Jones.—Can we help the case by changing the grade either above or below the angle?

Mr. Shreve.—I think not. We might help, by changing the form of the ditch at the curve so that the bank on the outer part of the curve would have more slope than the inner bank, on the principle of raising the outer rail on railroads.

Mr. Balcom.—How is the water going to pass through the soil when the cracks alluded to by Mr. Shreve become filled again by the running together of the soil while it is in a saturated condition?

Mr. Shreve.—Put the tile in deep and near together and wait for the action of the drains to produce the cracks. They will get there just as well when the drains are 3 feet deep as when they are 2 feet deep.

REPORT

OF THE

Second Annual Meeting

OF THE

ILLINOIS SOCIETY

OF

Engineers AND Surveyors,

HELD AT

Champaign, Ill., Jan. 26, 27 and 28,

1887.

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EZRA D. SHREVE...Bucyrus, O.

FRED J. SAGER...Columbus, O.

NOTE.

The attention of the members is called to the list of standing committees as given on page 4. By the constitution these committees are to collate facts, figures and experiments of interest in their respective departments, and make a formal report to the society. Questions of practice, usage, law, decisions of courts, improvements in methods, and other items of interest to the profession are included in the work of the committees. In case of any question of immediate interest to the society, bulletins may be issued. All queries should be addressed to the chairman of the proper committee. It is also suggested that individual answers be made to the questions of the members. In many societies the work of the committees is among the most valuable features. To secure such efficiency, personal effort and earnest work will be required of the committees. With them lies a large part of the success of the society.

The next annual meeting will be held at Springfield in January, 1888. Subjects thought to be of interest for papers for that meeting should be suggested by members as well as by the committees.

It is desired that the membership include every wide-awake and proficient surveyor, city engineer, drainage engineer, mining engineer, etc., in the state. Even to those who can not be present at the meetings, the annual report, together with the exchange copies from societies of adjoining states, will be well worth the small expense of membership. Members knowing competent and able surveyors and engineers who would make desirable additions to our roll will do well to inform them of the advantages of membership.

PROCEEDINGS

OF SECOND ANNUAL MEETING OF

Illinois Society of Engineers and Surveyors,

—HELD AT—

Champaign, Illinois, January 26–28, 1887.

WEDNESDAY—AFTERNOON SESSION.

The society met in the physical lecture room in the main building of the University of Illinois, at 3 o'clock, p. m., President I. O. Baker in the chair.

An address of welcome to the members of the association was extended in behalf of the University of Illinois by Professor T. J. Burrill, acting Regent. He closed his address by inviting the members of the society to examine into the different departments, libraries, laboratories and museums of the University, and hoped that the association would be able to set apart an hour of its time to a systematic visit, at which time he would be glad to act as guide and to explain the workings and methods of the University to all.

A response was given to the address of welcome by C. G. Elliott, Tonica, Ills., chairman of the Executive Board.

The President, Prof. I. O. Baker, Champaign, then delivered his annual address; after which Executive Secretary, A. N. Talbot, Champaign, reported the workings of his office during the year.

The Treasurer, Geo. P. Ela, Bloomington, was not ready to make a full report and asked leave to make a full report later,—granted leave.

The Executive Board by request was allowed to report as seemed best during the sessions.

Chairman Elliott made the annual report of the committee on Land Drainage and Public Highways.

The committees on General Engineering and Mining Engineering and the Legislative and Judiciary committee were granted leave to report at another session.

EVENING SESSION.

The report of the committee on Sanitary Engineering and Water Supply was given by Chairman Talbot.

Geo. P. Ela, Bloomington, chairman of the committee on National Public Works reported verbally that progress had been made and stated how the work of the committee was being performed and the object which it was hoped would be accomplished, and asked leave to file a written report and have same published with the proceedings of the association—granted.

A paper entitled, "Combined *vs* Separate System of Sewerage for Cities," was read by S. A. Bullard, City Engineer, of Springfield, Illinois. Discussion by members of the society followed.

"The License System for Surveyors" was presented in a paper by Samuel S. Greeley, Chicago. Discussion. Mr. Greeley's paper was closed with the presentation of a bill which he recommended as embodying the advantages developed in his paper. On motion the bill was referred to the Legislative and Judicial committee.

A report from the Executive Board was received recommending names of persons for membership. On ballot the following were elected members:

Fletcher H. Chapman	Carlinville, Illinois
John R. Lewis	Piper City, Illinois
Samuel S. Greeley	Chicago, Illinois
Thomas S. McClanahan	Monmouth, Illinois
Daniel W. Mead	Rockford, Illinois
George V. Loring	Decatur, Illinois
Frank V. Alkire	Petersburg, Illinois
Jacob T. Foster	Chicago, Illinois
Benj. J. Gifford	Rantoul, Illinois
Chas. W. Rolfe	Champaign, Illinois
Joel Dunn	Bement, Illinois
Geo. W. Dickinson	Charleston, Illinois
Hubert A. Stevens	Chicago, Illinois
Simeon C. Colton	Chicago, Illinois
Clarence E. Messer	Onarga, Illinois

THURSDAY—MORNING SESSION.

On motion a committee was appointed by the chair to confer with the Regent of the University to decide upon a time to visit the buildings and departments of the University. A. N. Talbot and D. L. Braucher, were appointed.

The Paper, "Topographical Surveys and Records for Drainage Purposes" was presented by C. G. Elliott, C. E., Tonica, and after discussion of Mr. Elliott's paper, A. H. Bell, Bloomington, read an article on "Some Hints on Field Work in Drainage Engineering." Discussion.

"Just Apportionment of the Cost of Drainage Improvements," by D. J. Stanford, Chatsworth, was next presented, and after the discussion the "Exterior Boundary of Townships" by F. Hodgman, was read. Discussion.

AFTERNOON SESSION.

Prof. T. B. Comstock, Champaign, read an article on "Oil and Natural Gas in Illinois," which elicited much discussion. Then followed the papers, "Reservoirs for Railroads, Mills, &c.," by S. F. Balcom, Champaign; "Perpetuation of Corners," J. S. Burt, Henry, and "Fractional Sections," Z. A. Enos, Springfield.

EVENING SESSION.

A lengthy and exhaustive illustrated lecture on Bridges was presented by Prof. I. O. Baker, Champaign, in which the principles of bridge construction were discussed, the writer claiming a superiority in design and workmanship for American over European bridges. The lecture was happily illustrated by means of the stereopticon with many of the largest and most renowned bridges of the world. On account of the number of illustrations which would be required, the lecture cannot be printed in the report, as desired by so many of the members.

Prof Baker was followed by D. L. Braucher, Lincoln, with a paper on "Importance of Accurate Measurements in Surveying," and after disscussion that was followed by E. A. Hill, C. E., Indianapolis, Ind., in an article on "Railway Trestles." Discussion.

FRIDAY—MORNING SESSION.

The paper of Geo. F. Wightman, Peoria, was read—"Pavements for Small Cities." Mr. Wightman had a specimen of brick used in

the pavements of Peoria, and Mr. Bell, Bloomington, showed specimens of common brick that had been in the pavements in his city for eleven and in one instance fourteen years; except for wear they appeared to be as good as when first put in.

The Executive Board made their final report. The recommendations were adopted, and the constitution was declared amended, so that the committee on Sanitary Engineering and Water Supply would read committee on Municipal Engineering.

The Legislative and Judiciary committee reported through chairman Bullard. The committee recommended that several changes be made in the laws of Illinois, affecting the work and standing of engineers and surveyors. On motion the report was accepted and the recommendations approved.

Under the order of "Decisions of questions in practice in Land Surveying," Mr. Foster presented the case of the north boundary of Sec. 4—37—14, in the county of Cook. The quarter corner on the north boundary of section four was known to one surveyor only to be 35 feet south of a direct line from the north-east to the north-west corner of the section. The government corner was lost and it is required to be reset. The question is, "Shall the corner be established on a right line between tbe north-east and north-west corners or shall it be set 35 feet south of said right line?" After a full discussson by the members, Mr. Foster introduced the following resolution: Resolved, That the north line of Sec. 4—37—14, be determined by running the line from the north-west to the north-east corner of the same. On vote the resolution did not pass.

The report of the committee on Mining was heard.

On motion of Mr. Greeley a standing committee was added to the list to be known as the committee on Weights and Measures.

Mr. Ela on behalf of the committee on National Public Works informed the association that the national meeting will be held in Cleveland in February.

Moved by Mr. Bullard that the committee on National Public Works be continued and that they be authorized to send a delegate to the national convention. Carried.

An amendment to Mr. Bullard's motion, that the association pay the necessary expenses of said delegate, failed to pass.

The report of the General Committee on Engineering was heard.

It was moved by Mr. Mead that the incoming president appoint a special committee to take charge of the legislation that is desired by the association. Carried.

The committee on Instruments, Blanks and Records, made their report.

After nominations by the committee and by members, the following officers were elected by ballot:

President	Prof. I. O. Baker
Vice-President	J. T. Foster
Executive Secretary	Prof. A. N. Talbot
Recording Secretary	S. A. Bullard
Treasurer	Geo. P. Ela
Executive Board	C. G. Elliott T. B. Comstock A. H. Bell.

Mr. Bullard introduced the following resolution and moved its adoption:

Resolved, That the thanks of this association be extended to Prof. Burrill, acting Regent of the University of Illinois for the kindnesses we have received while here, and to the faculty and students for the uniform courtesy they have shown the members of this association during their stay, and to Mr. Baker, janitor of the building, for his untiring attention to our comforts and wants throughout the sessions of this, our second annual meeting.

Carried.

The officers elect were installed. The new vice-president, Mr. Foster, making a brief address.

On motion it was decided to hold the next annual meeting in the city of Springfield.

The president announced the appointment of S. A. Bullard, Z. A. Enos and J. T. Foster, on the special committee to take charge of contemplated legislation. After which the president declared the second annual meeting of the Illinois Society of Engineers and Surveyors adjourned without date.

S. A. BULLARD, *Rec. Sec'y.*

PRESIDENT'S ADDRESS.

PROF. I. O. BAKER, OF CHAMPAIGN.

Gentlemen of the Illinois Society of Engineers and Surveyors:—

It was not until some time after the publication of our proceedings that I was aware that it devolved upon the President of this society to deliver an address at this time, and as the constitution and by-laws say nothing about it except to insert in the order of business the words President's address, I am at a loss to know what form of address was intended. As far as I have observed, such addresses are either the elucidation of some line of thought in the writer's own special branch of professional work, or a summary of progress in those branches in which the society is most directly interested.

I have chosen the second form of address in the belief that it is by taking a general survey, from time to time, of the existing state of knowledge in any branch that definite progress is most likely to be promoted. Our members are widely separated, and do not often have the benefit of discussing the engineering topics of the day with those engaged in kindred pursuits. It is believed that a summary of progress may serve to recall and fix in mind some items that might otherwise be lost.

The field of engineering activities is so extensive and the task of presenting a broad and comprehensive statement of the engineering progress during the past year is of such magnitude, that the speaker will not attempt a general survey of the whole field, but asks your indulgence while he refers briefly to such advances as he has been able to call to mind. As with the movements of the heavenly bodies actual progress can only be determined after a long series of observations, so in engineering matters a knowledge of the present and a comparison with the past are essential in determining the direction and amount of progress. Your president is the one whom you have placed at the instrument to make the annual observations; he now brings you the record. The results are uncorrected for personal equation, instrumental errors, refraction, aberration, and proper motion. Possibly your observer has not made his observation at the critical moment, and therefore his results may show a retrograde instead of a direct motion; and he may have made an error in the record of the star observed, or have been guilty of observing the position of the stars whose places are well known and neglecting those about which information is needed. Such as they are, he gives you his observations for the year; possibly in the future they will be

smiled at as we now smile at some of the crude conclusions of the ancient astronomers.

In the beginning we may inquire, what constitutes progress in engineering matters? If we consider the amount of engineering works constructed during any year as evidence of progress, then the advance each succeeding year is greater than that of any previous one in the history of the world. But mere repetition or duplication can not be considered real progress in engineering, any more than a multiplication of successive editions of a book can be considered progress in literature. It will probably be accepted, if we say that progress consists either in cheapening the process or improving the product of old processes, or in inventing something new, either in principle or combination. If this definition be true, it is not my duty simply to describe those works of the engineer which never fail to excite general admiration by being either the largest, or the most difficult; while a statement of the dimensions and cost of such works might be of some interest to the members of the society, such data together with detailed descriptions can be found in current numbers of the numerous excellent engineering journals.

There are many important branches of engineering for which, like the movement of the stars, a year is too short a time in which to determine either the direction or amount of the movement; to this class belongs the use of steel in construction, the problems of river improvements, the questions relating to naval warfare, railway machinery, etc. Although we may not be able to determine the orbit of any of these, we may still affirm "it moves nevertheless."

RAILROADS.

Since the construction and operation of railroads is one of the most important branches of engineering, and since they both directly and indirectly exercise a marked influence on the industries of the country, it seems only proper to begin this review with an examination of the progress in railroad matters. In 1886, 7026 miles of main line, or about 8649 miles of track, were constructed; this is 4,400 miles more than the year before, the largest since 1882, and was never exceeded but twice; the total main line in the country is now about 130,000 miles and the total track about 160,000. The new road built last year involved an expenditure of about $85,000,000. A portion of the work has been done in opening up new territory to the visits of commerce; but a large part, perhaps the larger, was in territory where the existing lines were already adequate; if it were not that most of the new lines were built under the auspices of old companies, it would be safe to prophesy disaster to the roads themselves and consequently a depressing effect upon the industries of the country. It does not seem possible that this activity of railroad-building can be kept up much longer, but the prospect for the coming year is believed to be at least equally as good as for the one that has just lapsed into history.

On the technical side, the most important event of the year probably was the test of continuous freight train brakes at Burlington, Iowa, last summer under the auspices of an association of railroads. The experiments will be continued next spring. The increase of freight to be moved, which is double, per mile of road, what it was 30 years ago, makes it necessary for the trunk lines either to build double tracks or find some means of moving freight trains more rapidly. With the frequent stops, heavy trains, and hand brakes, the speed must of necessity be slow; but if a satisfactory power brake can be found, the velocity of freight trains can be doubled easily, thereby greatly increasing the capacity of the roads without anything like a proportionate increase in expenses. It is highly probable that some form of automatic brake acting throughout the length of a freight train will ere long be very largely adopted; at present, only about 4 per cent. of the freight cars are provided with power brakes.

The adoption of safety couplers, toward which the roads seemed hastening a year ago, appears to be more remote now. The general belief has grown broader and stronger during the year that railroads will soon have to adopt some form of coupler less dangerous than the one in use, protect their trains by a much more general use of the interlocking and block systems, expend large sums to put their tracks above or below frequented streets in the towns and cities along their lines, and provide some means for passing railroad crossings at full speed. Since the opening of the new year, interlocking switch apparatus has been introduced at a number of points, in some cases on roads where it had not been used hitherto. It is reported that the Lehigh Valley R. R. is to be equipped with the Phelps system of train telegraphy, by which moving trains can be kept in constant communication with any station on the line of the road.

Incidentally, during the Burlington brake tests, it was shown that the train resistance in pounds per ton for the average service of this country is about $3.5 + \frac{v^2}{367}$, which is much less than that given by the formula in general use, which however was known to give a result much too large. These are the first observations of any considerable accuracy on the resistance of American rolling stock.

The Pennsylvania Railroad Company is building at its shops in Altoona thirty freight engines weighing 114,000 pounds, or 107 tons. They rest on four pairs of drivers and a pony truck, have a 60 inch boiler and 250 flues. These engines are to haul the cars the company is building of fifty-ton capacity, which are built proportionately strong. These monsters are a menace to existing bridges.

As yet there is nothing like a general movement towards the adoption of preserved ties; however it is certain that progress has been made in that direction during the past year, doubtless largely due to the exhaustive report on the preservation of timber made by

a committee of the American Society of Civil Engineers. Extensive works for preserving ties have been erected at Laramie, Wyoming, and at Las Vegas, New Mexico; the Rock Island road is also doing something in that direction at Chicago. The importance of such a movement is at once seen when it is remembered there are about 500,000,000 ties in the roads of the United States, that the average life is about 6½ years, and that therefore about 77,000,000 are required annually, which, when in the track, represent an annual expense of 30 to 40 million dollars. Any process which will double the life of a tie, which it seems possible to do, will effect an annual saving of this sum. No country can afford this enormous waste, this prodigal squandering of its inheritance.

Our forests are being exhausted, without any adequate means being taken to provide a supply for future demands. There are those who believe that the denudation of our forests will seriously affect the climate and the flow of our rivers and other streams, but of this the writer has yet seen no evidence, and does not believe that cutting off the forests will affect these elements to an appreciable degree. The necessity of timber for general purposes, its comparatively limited supply, and the certainty that other material than timber is applicable for railroad ties, make it very desirable that this great drain on our prospective supply should be stopped. At present the cost of a substitute for wooden ties is so great that the roads find it cheaper to use unpreserved wood ties than preserved wooden ones or any substitute for wood, the policy of the roads being to provide for present dividends and allow the future to take care of itself. The importance of the subject is great enough to warrant the government, either general or state, in taking some action which shall preserve our timber supply from heedless waste.

Some of our roads are making experiments with iron ties; the Pennsylvania road during the past year laid 2 miles with iron ties of inverted channel section. Glass sleepers have been manufactured in Germany, but to what extent used is not known to the writer. The use of steel ties is rapidly extending on the Vera Cruz R. R. in Mexico; 20,000 are now in use, 40,000 more were ordered from England the past year, and it is proposed to put in 40,000 to 50,000 per year. The cost in England is $1.25 apiece.

A number of western roads are experimenting with burned clay for ballast, one having put in 40 miles, which is said to give excellent results, and not to be expensive, nor difficult to burn.

During the year the most, if not all, of the so-called broad gauge roads of the south were changed to standard, which is obviously a great improvement.

The most interesting publication on railroad matters during the year was a paper, read before the American Society of Civil Engineers, comparing the cost of constructing and operating English and American roads, which showed unexpectedly favorable results in the methods of railroad management in this country.

STREET RAILWAYS.

The continued disposition of people to mass in cities, together with an increasing desire of the inhabitants of the cities for the fresh air and green fields of the country, makes the question of rapid transit in the cities one of increasing importance. There is probably not a large city in which there is not a serious need of a more rapid and convenient means of getting to and from business than by horse cars. The past year has shown great activity in this direction.

The system of elevated railways is remarkably successful in the city of New York, and is being extended to the suburban districts north of that city. Their success in New York has lead several other cities to try them; there are several lines in operation, or in progress of construction, in Brooklyn, Kansas City, and Pittsburgh.

The first cable street-railway in San Francisco in 1873 was looked upon as an experiment; but after a satisfactory trial of three years, the system having proved itself a mechanical and financial success, a second road was constructed, also in San Francisco. This was followed by others in rapid succession, until that city has at present upward of twenty miles of cable-roads in operation. Other cities followed the lead of San Francisco; Chicago in 1882, and now has 10 miles, with more in progress; Philadelphia and Kansas City in 1885, the former with 12 miles and the latter with 8; St. Louis in 1886 with 16 miles. Numerous shorter lines bring the total length of double track cable street-railway in the United States nearly if not quite up to 160 miles. It is proposed to gridiron New York City with cable street railways. Taking into consideration with this the fact that cable-roads are making rapid headway in Europe, Mexico, Australia, and New Zealand, it will be seen that the new system of street-car traction has proved its right to a prominent position in railroad economics. It is better adapted to short than long lines.

The electric motor is destined to play an important part in the history of railroads in this as well as other countries. Although not yet out of the experimental stage, electric street railways are rapidly gaining ground in public favor. Chicago, Appleton, Wis., Fort Wayne, Ind., Cleveland, O., Baltimore, Philadelphia, Minneapolis, Toronto, and perhaps other cities, already have electric street-railways in successful and profitable operation. About a dozen new roads are in course of construction, and a score or two more are projected. It is said there are 84 railroads employing electricity as motive power. Montgomery, Ala., will be the first city in the world to have a complete electric street-railway system. During the year the system of carrying the electricity for operating the motor along with the car, in a storage battery, was tried in England; the result is not known. This method offers the very great advantage of doing away with the conductor for carrying the current from the generating station to the cars.

In this connection it is interesting to note that the experiments of M. Deprez, at Creil, France, shows very considerable and substantial success in the transmission of force to a distance by means of electricity.

CANALS AND SHIP RAILWAYS.

While the demand for rapid transportation has brought the construction of inland canals to a stand still, it has stimulated the construction of ship canals. From the most important of these, the Panama, the reports are as conflicting as ever; M. de Lesseps has very recently reiterated the assertion that it will be opened in 1889, while the impression is gaining ground among engineers that if completed at all it will be as a canal with locks. The report of the agent sent by the New York City Chamber of Commerce was very disappointing; it was very unfortunate for the interests of engineering that a thoroughly equipped engineer was not also appointed on the committee.

The project of a Nicaraugua ship canal is still being agaitated, a bill therefor having recently received favorable action from the committee on Foreign Relations. The late report of the army engineers can hardly be considered favorable to the Hennepin canal, although there seems to be a difference of opinion about even that. It has been proposed that the states most interested take the job, and dig it by convict labor.

The papers announce that the promoters of the Tehuantepec ship railway have abandoned the hope of government aid, and expect to construct it entirely with private capital. The construction of a ship railroad from the Gulf of St. Lawrence to the Bay of Fundy, similar in its details to those proposed for Tehuautepec, is now under way, and the project of a ship railroad across the peninsula of Florida is being discussed.

For the present, the construction of the proposed Manchester ship canal is off, the necessary capital not having been subscribed within the time-limit allowed by act of Parliament. It will be tried again next year. Ship canals are in contemplation, and are reasonably certain of being carried out in the near future, between the Baltic and North sea, and between the Baltic and the White sea.

TUNNELS.

Tunneling, now-a-days, can be done much more expeditiously and cheaply than formerly, in consequence of the improvement in drills and in explosives, coupled with the more perfect ventilation due to the use of compressed air. The results have shown themselves in a constant increase in the rate of advance. Thus, in the Mont-Cenis tunnel the average rate was 1.75 meters a day. In the St. Gothard tunnel, where more powerful explosives were used, the rate was 2.75 meters. In the Arlberg tunnel further improvements in the drills and explosives used, with a better organization of the

work, raised the work of daily advance to 4.15 meters. More recently the Levant tunnel was driven at a rate of 4.50 meters a day; and the last great work of this character, the Carrito tunnel in Italy, where blasting gelatine was used in deeper holes than dynamite could work in effectually, shows an average daily advance of 5.40 meters. Some allowance must, of course, be made in these estimates for difference of rock and other conditions of the problem; but as these averages are for the whole work, they represent approximately the progress made in the science and practice of mining since the completion of the Mont-Cenis tunnel.

The two principal tunnels completed during the year were the Severn and the Mersey. The former, which shortens the distance between England and the coal-fields of south Wales, was commenced in 1873, is $4\frac{1}{4}$ miles long, of which $2\frac{1}{4}$ is under the river-bed; roughly the cost was $500 per foot. The Mersey tunnel connects Liverpool and Birkenhead, the latter being to the former as Brooklyn to New York City; it was commenced in 1879, is $2\frac{3}{4}$ miles long, and has two underground passenger stations communicating with the surface by hydraulic lifts. Neither of these tunnels offered any serious engineering difficulties; in both the rock yielded easily to the drill and yet was strong enough to support the over-lying earth.

Among the foreign tunnel projects on foot is one each under Mont Blanc, Northumberland Strait, and Dover Strait, all of which will involve interesting engineering features.

The principal tunnel completed in this country the past year is the Vosburg tunnel, in Wyoming Co., Pennsylvania, on the Lehigh Valley road, undertaken to improve the alignment of that road; it is $\frac{3}{4}$ of a mile, and presented but slight engineering difficulties. The construction of the Cascade tunnel on the Northern Pacific railroad is in progress; when completed it will be, next to the Housac, the longest railroad tunnel in America. There seems to be some prospect for the revival of the tunnel under the Hudson.

The tunnel for the New Croton, aqueduct for supplying water to New York City is progressing rapidly. The total length, including two branches is a little more than 33 miles, all but about 3000 feet being tunnel; the main stem is 24.2 miles long, of which 14.8 have been completed. This is very much the longest tunnel in the world.

BRIDGES.

The past year has been one of unusual activity in bridge construction, quite a number of important structures having been completed, of which the St. John's river (New Brunswick) cantilever is the most interesting. Among the more important bridges in progress is another over the Ohio at Cincinnati, one across the Hudson at Poughkeepsie, the Tay bridge, which is nearly completed, the Forth with its two spans of one third of a mile each, and the Sukkur bridge across the Indus having a span of 790 feet.

The present year promises to eclipse any former one in bridge construction; a large number of bridges are proposed, which derive importance from the difficulties likely to be encountered in sinking the foundations, or from the length of span. The extremely low price of iron and steel greatly favors the selection of long spans for bridges, as the saving in piers and foundations balances the extra cost per linear foot of long spans. On the other hand, the great increase in the weight of both locomotives and trains, as already noticed, has increased the difficulties of constructing long span bridges. Since the great success of the Cantilever at Niagara Falls. a number of other bridges have been built on this principle, and by far the greater number of long span bridges lately proposed are to be cantilevers, as this system offers great advantages in erection. Among the bridges proposed, and which will probably be commenced this year, are those across the Mississippi at Keokuk, Alton, St. Louis, and Memphis; one across the Ohio at Cairo, four or five on the lower Missouri, and the Storm King Bridge over the Hudson. Bills have been passed authorizing brides at Detroit, Cincinnati. Vicksburg, and across East river at New York City.

MUNICIPAL ENGINEERING.

This is a branch of engineering which could profitably receive greater attention from the engineering profession than at present; those branches of engineering which so directly influence the health and comfort of our cities, which constitutes so great a proportion of our total population, are worthy of the best efforts of engineers. Some of the masterpieces of American engineering have related to this branch of the profession. It is continually growing in importance, of which the last year furnishes abundant evidence.

The list of small towns which have erected water works is very long, and extensions are in progress or contemplated in a number of the larger cities. The increase in heighth of buildings owing to the introduction of the elevator, the great increase in late years of the amount consumed per capita, and the development of manufactures, have made demands upon the water works of our large cities undreamed of at the time of their construction; hence the extensions. The most important and extensive works for the supply of water. which are being carried on at present, are those of New York, Liverpool and Washington. But little has been done on the latter during the past year, for lack of funds. The Aqueduct tunnel of the New York works which is 33 miles long is progressing very rapidly; the most interesting feature of the work is a proposed masonry dam 178 feet above the bed of the stream, and nearly 300 feet above the bed of the foundation, the width at the bottom being nearly 200 feet. The construction of this dam involves important engineering questions. The Liverpool works are of a strikingly similar character. and of hardly less magnitude.

A new method of investigating drinking water has been intro-

duced, which consists in examining the number and species of bacteria in it. This has proved, in many cases, of great value in supplementing other methods of examination. Many of those prominent in matters pertaining to public hygiene, are inclined to look upon this method as more satisfactory than chemical analysis. An interesting and promising field is thus opened up.

Questions relating to sanitary science have received increased attention the past years, as well they should, since man with all his superiority of knowledge and skill lives but two-fifths of his natural life, as compared with the brute creation. In the words of a learned report: "It is now established beyond a doubt that sanitary measures in their true sense, and sanitary measures alone, are the only trustworthy means to prevent outbreaks of disease, and restrain its spread and mitigate its severity when prevalent." The most important work of the engineer, in its effect upon the health of a community, is in the matter of sewerage. This branch has been the subject of elaborate investigations and able reports on both sides of the ocean. The metropolis of our own state has a difficult problem of this kind on hand, which is being worked at in a thorough and scientific manner and will unquestionably lead to valuable results. In the general discussion the necessity of a separation of the rainfall from the sewerage seems to be gaining ground.

In the management of municipal affairs, no one item of expense aggregates more than that of improving and keeping the streets in repair. In the large cities granite blocks, wooden blocks, and monolithic asphaltum are almost exclusively used; each has its peculiar advantages and disadvantages, but none of them are suitable for the smaller cities of our state. The brick pavement gains in popularity with use; Charleston, W. Va., has had long and satisfactory experience with it; it has been extensively adopted in Wheeling, W. Va., and Stubenville, O.; Bloomington, Decatur, Jacksonville and Galesburg have laid comparatively large areas of it during the past year, and will continue it next. Camden, N. J., and New Orleans have laid an experimental section. A small experimental section of iron pavement has lately been laid in Chicago. The experiment of covering the unpaved streets with cinders and ashes has been tried in Toledo, O., with very satisfactory results; the first year a 6-inch covering "became remarkably compact, and formed so good a roadway that the most heavily loaded wagons did not cut through it even during the open weather of the past winter. During the dry period this summer it did not become nearly so dusty as the ordinary earth roadways." Although this is not equally applicable to all localities, it may be a valuable hint to some.

There is a pause in the battle, which raged so fiercely a year ago, in this part of the country at least, between the electric and gas lights for street lighting. The latter appears to have the better of its competitor. Apparently the tower system of electric lighting is being abandoned.

The removal of telegraph, telephone, electric light and power wires, and poles from the streets of cities and towns is proceeding slowly, partly because the best means of securing insulation, preventing induction, etc., have not yet been determined.

FUEL.

It is not necessary to dilate upon the importance of this element in the civilization of to-day. During the past few years, owing to the discovery of natural gas, the fuel question has acquired a new interest, not only in the substitution of natural gas for coal, but also in the more economical use of coal. It has long been well known that the processes of combustion were wasteful in the extreme; ordinarily 75 to 90 per cent. of the thermic power of coal is lost. The past year has witnessed considerable progress in the direction of diminishing this waste. Investigation and invention have been busy seeking to find substitutes for solid fuels.

The very great advantages obtained by the use of finely pulverized fuel has not received the attention its merits deserve.

Although the question of the utilization of liquid hydro-carbons as fuel is of no recent date, the increase of residual oils produced from gas works, coke ovens, smelting furnaces, etc., and the discovery of new sources of petroleum, particularly the very rich one in Russia recently, has caused this question to receive increased attention. Great interest is being taken in Europe, especially in England, in the use of petroleum as a fuel; and considerable advance has been attained during the year, many applications having been made to stationary boilers, furnaces, and to torpedo boats, and ocean-going steam ships. With crude oil worth only one-eight of a cent per gallon in Russia, with a pipe line to the sea-board under construction, together with cheap ocean freights, the use of petroleum offers great possibilities.

On this side of the ocean the discovery of natural gas has given the impetus to thought upon this subject. No one questions the desirability of a gaseous over a solid fuel. It begins to look as though the days of solid fuel for many purposes were numbered, and that we shall soon usher in the new candidate for public favor, and transform all the solid fuels into gaseous before using. Natural gas has forced the issue. At Pittsburg it has caused a revolution, having almost entirely displaced coal; it is used exclusively in 400 manufactories and over 7,000 dwellings in that city. It is largely used in rolling mills, smelting furnaces, glass works, etc., situated in the natural gas districts. A cubic foot of natural gas is equivalent in heating power to 55 pounds of anthracite coal.

The search for natural gas, and its exploitation, is being conducted with wonderful vigor. In Western Pennsylvania alone there are incorporated at least fifty-two natural gas companies. It has been known in Ohio for some time, and has very recently been

discovered in apparently paying quantities in Northern Indiana. There is some indication that it may also be found in paying quantities in Illinois, Kentucky, Missouri, Kansas, and possibly Wisconsin. The possibilities are fascinating, but the probabilities are shrouded in the darkest mysteries of the depths of the earth. With reference to natural gas in our own state, the results so far appear to indicate that while the Illinois fields may furnish household supplies, they will probably cut no figure in supplying power for manufacturing purposes, even if they hold out for domestic uses. Possibly a small field near Litchfield, Montgomery county, is an exception to this conclusion, natural gas being now used in 400 stoves in that town; the nature of the source of supply of these wells differs from all others in the state, and somewhat resembles those of the Pittsburg district.

Natural gas is a sectional product, and as yet it has not been found practicable to pipe it farther than about 30 miles. In localities not favored with gas from the reservoirs of nature, great attention has been given to the production of gas from coal. Although water gas has been known and employed for many years, the difficulties in the way of its successful commercial introduction has of late years been so far overcome as to make it a competitor with natural gas for a cheap and efficient fuel. It is claimed that water gas can be manufactured at the anthracite mines from marketable coal for 10 cents per 1,000 feet, and for 2 cents by using culm or waste coal, of which there are great mountain piles about all the mines. The efficiency of water gas varies from 60 to 80 per cent. of the thermic power of the coal from which it is made. The advantage of its use being derived from the fact that in burning the gas nearly all its heat is realized, while in consuming the solid coal the major part is lost.

In the bituminous coal regions the many advantages of gaseous fuel can be secured by the manufacture of ordinary illuminating gas to be used as fuel also. The Dominion Bridge Company, of Montreal, Canada, one of the most perfectly appointed on this continent, use only gas made from slack brought from Nova Scotia. There is unquestionably destined to be a revolution in the use of fuel; it seems to be coming rapidly, and although it may be delayed, it will certainly come. There is no remaining opportunity to doubt that the economies, as well as the highest results, lie in the use of gaseous fuel. There is also a possibility that the general use of gas for fuel may do away with the dangerous steam boiler itself, making a short cut directly from the producer to the gas engine. Again the possibilities are fascinating, and the realization appears entirely possible.

There seems to have been less progress the last year than the preceeding ones in the direction of smoke prevention. Coal users are slow to learn the wastefulness of the large volumes of black smoke sent out by locomotives, factory chimneys, etc., while the people at large seem equally slow to learn the ill effects of such smoke upon the public health, and the beauty and durability of buildings.

MINING ENGINEERING.

Neither the writer's labor nor his reading has been of a nature to warrant him in making any observations on this branch of engineering, farther than to call attention to one point. The state geological survey was completed some years ago, since which a large amount of data have become available by the opening of new mines and by the borings of prospectors; this additional data should be combined with the old, and new conclusions be drawn to aid in the explorations for coal and gas. At a number of places in the state considerable sums have been lost in prospecting for coal and gas, which probably could have been saved had the state pursued a more liberal policy toward its geological survey. Possibly the mining engineering section of this society can perform part of the duty thus neglected by the state.

PUBLIC WORKS.

About a year ago a movement was started among the engineering societies of the country looking to the establishment of a rational policy of public works. Since the movement has been misunderstood by some, and its main features lost sight of by others, the writer asks permission to present a few thoughts upon this subject. It is hardly possible to imagine a system of appropriation for public works more fatal to their efficient conduct, and more productive of disaster and extravagance than the present one. By this system engineering considerations are entirely disregarded. The fundamental evil lies in the method of obtaining and distributing the appropriations, not in their disbursement and application. The eradication of this, and the substitution of a rational system, is the question to which our voices and votes as citizens, and our action as a society should be turned. The first object of the movement is to create a healthy state of public sentiment in the matter of a policy of public improvements, and then a radical change in the entire system which misgovern our public works will soon follow. But not less important than such a material result would be the abolition of one of the most corrupting and demoralizing influences in national politics.

It is a mistake to denominate the movement a question of civilian *vs* military engineers, such a view is unworthy of a man of intelligence or integrity. With the remedy of the legislative abuses and the inauguration of some rational system, the formation of a Board of Control will naturally follow, which will secure the services of those men best fitted to marshal the forces of nature for man's benefit, whether their early training be civil or military. Such a board would formulate systematic plans, which would have unity of design and take cognizance of the relations of parts to the whole, so that the blunders and irrelevancies of the past might be avoided.

The improvement of our rivers made but little progress during the past year owing to the failure of Congress to make any appro-

priations. "The storage reservoirs which have been constructed on the Mississippi river 300 to 500 miles above St. Paul with a view toward regulating the flow of water in the river, were opened on the 1st of August, 1885, and have, so far as can be ascertained, fulfilled all reasonable expectations as to their effects, and it is probable that these results, achieved with a comparatively small outlay of money, will encourage the authorities to further steps in this direction."

DRAINAGE.

Drainage, especially the redemption of swamp lands, has become an engineering question of considerable magnitude. Illinois probably surpasses any other state in the extent of drainage enterprises. The passage of the new drainage law and the introduction of steam machinery has greatly stimulated drainage matters. After giving considerable time to it, the writer concludes that it is impossible to collect any reliable data as to the amount of work done during the past year; but it may safely be stated that the work of the past year has greatly exceeded that of any previous one. Fourteen steam dredges have been in operation in the state, and in the aggregate the open ditches cut by other means probably exceed the amount done by steam; the tile laid in 1886 is estimated by the tile-makers' association at 50,000 miles.

The process of redeeming land by drainage is going on in the United States at a much greater rate than the general public is aware of. The most important enterprise in this country is that of the Red River Valley in Minnesota, which involves the practical redemption of 1,500,000 acres. At the inauguration of this scheme last summer, your president was called upon to give an account of drainage matters in Illinois, and the execution of the preliminary survey was under the direction of the chairman of your executive committee.

HIGHWAY ENGINEERING.

A movement has been started in this state the object of which is to secure the advantage of engineering skill and ability in the care and improvement of the public highways; the movement originated in a paper read by the secretary of the state board of agriculture at the convention of highway commissioners held last April. Since the improvement of the public highways of the state is a question of great importance to the general public, I recommend that this society take such action for forwarding this movement as it is deemed best and proper, and suggest that great care be taken to throw about it all the safeguards necessary to secure engineering ability and efficiency.

CONCLUSION.

In conclusion, I congratulate you on the first year of our society, and the interest it has awakened in the engineers and surveyors of

the state. I am a firm believer in the usefulness of such organizations; people devoted to kindred pursuits have naturally much in common, and a society like this brings them togother, to compare notes and exchange experiences, and thus be of mutual benefit. The committee has provided an attractive program, and I desire to point out that the discussions which are supposed to follow the reading of the papers can also be made very profitable. If properly conducted, they can not fail to furnish suggestive and substantial nutriment. Each member should be encouraged to give his experiences, discoveries, inventions, and above all his mistakes, for all great men say that they learned more from their mistakes than from their successes.

I congratulate you also upon the appearances and substances of our first annual report; for its neat appearance the executive secretary should have the entire credit. I urge every member to contribute to the pages of future numbers; a little incident of field or office practice will always be most acceptable to your associates in the profession, and probably many interesting points will thus be brought out. Finally, let us all work earnestly and harmoniusly together enobling and building up our chosen profession.

THE LICENSE SYSTEM FOR SURVEYORS.

By SAMUEL S. GREELEY, of Chicago.

The calling of the Surveyor is one of eminent respectability and usefulness.

In the first place it is ancient; not so old perhaps as that of the herdsman or the tiller of the soil, but certainly as old as the earliest efforts at organized community. Man was first a monad, then a nomad, and finally a citizen. It is when man looks for a local habitation, when he ceases to rove, and begins to squat, that he calls in the Surveyor.

When Abram and Lot became so rich in flocks and herds that the land could not bear them, Abram made the friendly suggestion to his young kinsman: "Let there be no strife between me and thee. Is not the whole land before thee? Separate thyself I pray thee from me. If thou will take the left hand, then I will go to the right; or, if thou depart to the right hand, then I will go to the left." No boundary lines or deeds of partition were needed, entire separation being the peaceful expedient. Later on, "When the Most High divided to the Nations their inheritance, when he separated the Sons of Adam, He set the bounds to his people according to the numbers

of the Children of Israel." Communities and families wanted fixed and separate dwellings. Then real estate became an object of desire, and the Surveyor must measure the land and fix the corners, whether by the thong of bull's hide, or by the natural unit of the man's stride. From the bull's hide to the transit and steel tape is but a step—as a reckless punster might call it, only a matter of de-tail.

Surveyors are a respectable, as well as an ancient class. Few go down to the penitentiary; fewer rise to the scaffold; while some achieve greatness, and more have greatness thrust upon them. Devoted to a pursuit, which stimulates the mind, while it invigorates the body, which invites respect and confidence, though it holds out scanty hope of wealth, the Surveyor usually surrenders worldly ambition, and like the priest, takes the view of perpetual poverty, though not usually that of perpetual celibacy. It was perhaps of him that the worthy knight, Sir Henry Wotton, sang in 1614:

> "This man is freed from servile bands
> Of hope to rise or fear to fall;
> Lord of himself, though not of lands;
> And, having nothing, yet hath all."

The Surveyor derives dignity from the material with which he has to deal. The immediate product of most men's labor is perishable in its nature, being made for the consumption of a day or a year. *He* works upon the only possession of man, which the common law has regarded as *real property*—upon the land and its subdivisions. "Heaven and earth shall pass away"—not, let us hope, in the near future; and, until the final cataclysm, muniments of title, and the unseen, but inviolable lines which the Surveyor draws, shall stand, as nearly imperishable as the results of human action can become.

A survey faithfully made, a knotty point wisely resolved, is an enduring monument to the skillful workman; while the hasty or bungling work of the tyro of twenty brings a shudder to the veteran of sixty as it confronts him on the inexorable page of deed or record.

This modest sketch will convince you, if the fact be not already stamped on the inner consciousness of every professional brother, that the Surveyor, like Charity, "vaunteth not himself, is not puffed up, doth not behave himself unseemly." If now an elder brother ventures to remind himself and the craft of our common dignities and responsibilities, it is not so much to boast of what we have done and been, as to spur himself and you to continue instant in well-doing, that we may leave to our successors in the trust a fairer heritage than that which we received.

Much may be done to this end by individual faithfulness and striving; something, too, perhaps, by winning from our state government the formal recognition which we think is fairly justified by the importance of our functions.

Let us inquire for a moment what the state has done and is doing in this regard.

It may be stated as a general principle, of almost universal ap-

plication, that whatever hinders or prevents the free exchange of commodities is an injury to the individual and a tax upon the community. If the individual be needlessly hindered in the free use of his labor or skill, he is, to that extent, of less value as a producer, and the state is thereby impoverished. All laws which confer upon an individual or a class the exclusive power to do that which others of equal skill and industry may do as well, are restrictions upon the free exchange of commodities, and the favor to the individual or the class is done at the expense of the community.

There are, of course, executive or official functions which must in their nature be entrusted to one individual appointed or elected for the purpose; clearly there can be but one governor, or one secretary of state, as there can be but one treasurer or recorder of deeds for the county.

Twenty years ago land surveying was regarded in the State of Illinois as such an official function, and up to that time all legislation was based upon that idea. It is interesting to note the progress made since that time; and at the same time to compare the laws of our own state touching Surveyors with those of the other states of the union.

Of the present 45 states of the union, 34 have provision for the election of County Surveyors, to-wit: Alabama, Arkansas, California, Colorado, Dakota, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Missouri, Mississippi, Montana, Nebraska, New Mexico, Nevada. North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah, Wyoming, Wisconsin, Virginia, Washington, West Virginia, Eleven states have no such officer, to-wit: Arizona, Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, South Carolina, Vermont. Of the 13 original states, 5 had County Surveyors, to-wit: Pennsylvania, Maryland, Virginia, North Carolina, Georgia; eight states had none: New Hampshire, New York, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, South Carolina. In eighteen states the business of surveying, so far as it is recognized by law, is specifically, or by inference, confined to the County Surveyor, to-wit: Alabama, Arkansas (except by order of court or by consent of parties), California, Colorado, Florida, Louisiana, Maryland, Mississippi, Montana, New Mexico, Nebraska, Nevada, Pennsylvania, Utah, Wyoming, Virginia, West Virginia, Washington. In twenty-two states non-official Surveyors are recognized, either specifically or by inference: Connecticut, Delaware, Dakota, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Michigan, Minnesota, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, South Carolina, Tennessee, Texas, Wisconsin. In five state no mention of Surveyors is found in the statutes: Arizona, Massachusetts, New Hampshire, Rhode Island, Vermont.

The following are the provisions by statute in Illinois relating

to the duties and powers of County Surveyor:

1. He must take the oath of office.

2. He may appoint deputies, for whose official acts he shall be held responsible.

3. He must make, by himself or deputy, all surveys that he may be called upon to make within his county.

4. He shall provide himself with a well-bound book, in which he shall record all surveys made by him. This book shall be open to the inspection of persons who shall think themselves interested; and it shall be transmitted to his successor in office.

5. In case of alleged trespass upon lands by mining thereon, it shall be the duty of the judge before whom complaint shall be made to appoint some County Surveyor, or some other competent and suitable person, to make examinations and surveys, and to report.

6. County Surveyors may act as road viewers in their respective counties without further qualification, and may administer the oath of office to other road viewers associated with them.

7. The owner of any land desiring to lay out the same into a town or addition, or to subdivide the same, shall cause the County Surveyor, or some other competent Surveyor, to survey and plat the same.

In case of the sale or partition of the lands of a deceased person or of a ward, the administrator, commissioner, or guardian shall cause the same to be surveyed, platted and certified by a Surveyor or Engineer.

It will be seen that there is no official act or duty of the County Surveyor which may not, under the law, be performed by any other competent person.

The private Surveyor takes no oath, except for the performance of specific acts, he cannot appoint deputies, and he need not keep and exhibit a record of his work. In every other respect he is the peer of the official Surveyor; in these he is his superior, having equal powers and less obligations.

The six neighboring states most nearly resembling our own in position and real estate activitity are Ohio, Indiana, Wisconsin, Iowa, Missouri and Kansas. In all these the duties of the County Surveyor is substantially the same as in Illinois. In populous counties an important and profitable part of the Surveyor's work consists in laying out towns and additions. In Ohio, Indiana and Wisconsin, as in Illinois plats of new towns, villages and additions may be made and certified by any "competent" or "practical" Surveyor. In Iowa, Missouri and Kansas owners of land desiring to lay it out in lots are required to record a plat of the same, but the law does not specify by whom the plat shall be made. It is inferred that it may be done by any competent person.

We may congratulate ourselves upon the growth of liberal legislation in Illinois within the last twenty-five years. Up to 1863 the statutes required that all plats of towns, additions and subdivisions

should be made and certified by the County Surveyor, or by the City Surveyor, if within the limits of a city having such an officer. In a populous and rapidly growing county like Cook, or in a city like Chicago it was manifestly impossible for the official Surveyors to do promptly and well all the surveying that was required from 1854 on, and it became the custom for private Surveyors to do a large share of the work, paying the County or City Surveyor a considerable fee for attaching his certificate to each plat or subdivision intended for record.

In 1863 the new charter of the City of Chicago provided that the Board of Public Works might issue licenses to persons known to be competent, who, upon taking the official oath, filing a bond in the penal sum or $2,500, and recording the license, became Licensed Surveyors; and their acts as such had like effect and validity as those of the City Surveyor. In 1867 an amendment to the city charter extended the powers of Licensed Surveyors over the whole County of Cook, thus giving Licensed Surveyors co-ordinate jurisdiction with the Surveyor of the county. In 1869 the office of City Surveyor of Chicago, having lost its reason for being, was abolished by by the legislature. As a consequence of all this enlightened legislation, the work of the private Surveyor was greatly increased. New and well organized offices sprang up, freedom and the increasing demand induced competition, but it was a competition in increased skill and diligence and improved methods, and not in reduced prices. For the last twenty years the business of the Surveyors in Cook county has been in the main well conducted and prosperous.

In the revision of the state statutes in 1874 the words "or other competent Surveyor" were inserted after the words "County Surveyor" in the section relating to town plats, and in other sections relating to the division of land. From that time the business of surveying in Illinois ceased to be a monopoly in the hands of one man in each county, whose reputation as a Surveyor or whose influence as a politician enabled him to secure an election as County Surveyor.

Probably in the early history of a state, when the country was new, the people sparse, and the demand for surveys small, it was wise to induce some man having a knowledge of surveying to settle in each county by insuring to him whatever work was to be done. It would be simply the policy of fostering an infant industry by a prohibitory tariff—a policy which has found many and vigorous defenders. But as farms were taken up and population increased, there were towns to be laid out, roads to be surveyed, and drainage works to be engineered; the Surveyor's work was greatly increased and more skill was required for its performance.

Of course, many kinds of work could be done under the old law by others than the County Surveyor, but the more profitable part of the work, as subdivisions, partitions, etc., could be done only by him; and the prestige of the office led many persons to believe that no survey was legal or of much value unless done by the County Sur-

veyor. At this stage of development it was clearly an absurdity to limit the work to one man, and so to practically exclude other skilled men from the county; thus the law gradually grew to its present form.

The present law is in the main satisfactory, so far as the removal of the old monopoly is concerned, but it seems to take away all reason for existing from the office of County Surveyor. For why go to the expense of electing an officer to do that which, by the terms of the statute, any other skilled person may do as well as he?

If the candidate for this office be a competent Surveyor, he can, under the statute, perform all the functions of the office just as well without an election as with it. If he be not competent, all the ballot boxes in Illinois cannot make him so, though the law may presume competency from the fact of election.

Nearly all the business of a County Surveyor lies in his private practice, with which the county, as a municipality, has no more to do than it has with the private practice of a lawyer or a doctor, or with the business of a merchant or a mechanic. The county may need from time to time, or all the time, the service of a Surveyor, as may any other corporation. If such need be constant, and the service can be got more cheaply or more conveniently by the year than by the piece, there is certainly no more objection to the employment of a County Surveyor by the year than there is to the appointment of a County Attorney or a County Physician. Otherwise there is as little reason for it as for setting up a County Mason or a County Cobbler, because the commissioners now and then want to build a court house or get their boots tapped.

Our present laws have, as I have already shown, abolished the monopoly formerly existing in favor of County Surveyors; but the movement for the license system has another main object in view—the protection of the people against incompetency and quackery in Surveyors, and the placing of the work of the Surveyor on an equal footing with other callings which involve special scientific knowledge and training and require thought and study rather than manual skill.

It is no doubt true, as a general statement, that business thrives best when least hampered by legislative restrictions, and that competition, freedom of action, and the law of supply and demand are the great regulators of trade and dealing. Other things being equal, you buy of or employ the man who gives you the best article or service for the least money; and if you are sufficiently familiar with the comparative value of the article offered, this is a safe rule of action.

The carpenter is usually a good judge of the temper and hang of an adze or a chisel, and knows which make he prefers; the farmer quickly learns the relative value of the different ploughs and hoes, and the performance and durability of the various styles of reapers, threshers and drills; the surveyor is not often badly deceived in his purchase of a transit or a level; and we can all suit ourselves with hats, clothing, and the thousand articles of daily use, without risk of

serious loss. We soon become fair judges of articles whose qualities we put to daily test. If our judgment occasionally go astray, and we unwittingly take iron for steel, or shoddy for staple, the loss and annoyance are transient, ceasing with the life of the delusive tool or garment. So that the law wisely leaves us to take care of ourselves, and to the general remedy of a recovery of damages for losses sustained.

The case is quite otherwise with another class of objects or services, which we use less frequently, and with which we are less familiar, or whose value and effects are more or less hidden from view, or whose results are more permanent for good or evil. Here the law intervenes, frequently with the best results, to protect the public, either by forbidding or restricting the sale of articles, or by limiting trade or service to those whose qualifications have been ascertained.

Thus in cities the plumber and drainlayer must take out a license, on the theory that only responsible and skilled men will be allowed to work at these trades. Health and comfort are largely affected by the skill and good faith, or want of them, which these men put into their work; but sewers and water pipes are hidden under ground or in walls, whence disease and death may steal in upon us unawares. The municipal government may therefore very properly keep this class of operations under such control, as a license, and the fear of its revocation, may impose; the more especially because they affect public property in sewers and street mains, which could not safely be tapped or tampered with by unauthorized persons.

The restrictions placed upon practitioners of law and medicine rest upon the same considerations of public security. Life and health are largely at the mercy of the doctor; but the sick man and his friends have often no assurance of the doctor's skill, except by watching the tedious and costly process of a cure, and no warning of incapacity, till it is too late to shun it. So, too, the lawyer deals with specialties, of which the people have but small knowledge. We can not judge of the validity of a plea, a deed, or a will, as we can of the strength of an ox yoke, or the fit of a coat; yet on these often depends the security of an estate, or the life-long peace of mind of families.

A statute can guarantee neither ability and success in a lawyer and doctor, but it can and does insist that those who assume the delicate functions of these professions shall have had opportunity for education afforded by a professional school. Accordingly, in this State, a person wishing to practice medicine must present to the State Board of Health a diploma from a recognized medical college, or he must pass an examination by the Board. An attorney or a counsellor, before admission to the bar, must get a license from some two of the jnstices of the supreme court, having first presented to them a certificate of good moral character from a court of record in some county of the State.

The effect of these laws, besides affording evidence of some study, is to give a certain character and dignity to the profession, and to make members of them interested in the fitness of future licentiates. It seems certain that by this means the public secures the services of better doctors and lawyers than would be got if no inquiry were made into their character and preparation.

The bill which was offered in the legislature of 1879, is now presented for your consideration. Its object is to provide for the licensing of State Surveyors upon proof of good moral character, professional skill, and acquaintance with the theory and practice of U. S. land surveys. It seems to me that there are valid reasons for a law of this kind, and that it will be of advantage both to the public and to the body of surveyors. The work of the surveyor is in some respects not unlike that of the lawyer and the physician. It involves certain qualities, of the presence of which the public can not assure themselves any more readily than they can of the skill of the legal or the medical man. These qualities are integrity, sobriety, a knowledge of elementary mathematics, and of the system of public land surveys as laid down in the laws of the U. S. and in the instructions of the surveyor general, and so much plain, common sense, as will enable him to apply his knowledge to the case in hand.

The absence of such an equipment may not be apparent to employers, especially in a new and unknown man, and may perhaps not cause *immediate* damage; yet it may sow the seeds of endless litigation in the future.

The general fitness of a surveyor can be determined with reasonable certainty by the examining board, through an examination of the candidate, and of such witnesses, expert and other, as they may choose to hear; and I think no tolerably competent man need shrink from the test. Such a scrutiny is not, of course, an infallible proof of skill, nor a warrant against errors, but it shows precisely the same sort of foundation to start with that admission to the bar, or the diploma of a physician shows; neither more nor less.

A commission as State Surveyor could certainly be readily got by most of the old practitioners; and it would be within the reach of any young man of ordinary ability and fair technical education, who had served for a few years under an established Surveyor in the state, so that no privileged class is created by this means, nor is competition stifled.

On the contrary it is believed that the system would in a few years develop a large body of educated, intelligent and able Surveyors, the peer in their way of the bar and the medical profession. Surveys would be safer, and less liable to dispute, because more intelligently executed. It is probable that, if this improvement should result, Surveyors might ask, and the public be willing to pay, higher fees than are usual in some counties; and this would be good economy in the end. It is cheaper to pay full price for a good survey than to

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invest half the money in a slovenly job, with a lawsuit or a neighborhood quarrel on top of it.

It is not too much perhaps to expect that a spirit of comradeship would grow up which would lead the Surveyors to associate in societies like this for mutual improvement, the interchange of technical knowledge, and the discussion of difficult or disputed points in surveying. In this way both employers and Surveyors in one section might profit by the skill and experience of Surveyors throughout the state.

It must not be inferred from what has been said of the office of County Surveyor that the proposed plan involves the abolition of the county office, or that it implies any hostility to the incumbents. It in no important way enlarges the privileges of the non-official Surveyor, or widens the functions which he may perform. The private Surveyor will be no more the rival of the official Surveyor than he is at present.

It is greatly to be hoped that most of the official Surveyors of the 102 counties in the state will heartily co-operate in the movement, and will be among the first to offer themselves as candidates for examination.

It is probable, indeed, as I have already hinted, that the office of County Surveyor may in time be found useless, and may like many another obsolete institution drop into innocuous desuetude, but the change is hardly likely to come about within the official life of the present incumbents, or of their immediate successors.

[By request of Mr. Greeley, the bill which was prepared by the Legislative and Judiciary Committee of the Society, and which was introduced into the General Assembly by Representative Neely February 15, 1887, is here substituted for the bill read by Mr. Greeley.]

A BILL

FOR AN ACT TO PROVIDE FOR THE EXAMINATION AND APPOINTMENT OF LICENSED SURVEYORS.

Be it enacted by the people of the State of Illinois represented in the General Assembly:

SECTION 1. That the Governor of the State of Illinois shall nominate and (by and with the consent of the senate) appoint three surveyors who shall be commissioned as licensed surveyors to be called "The State Commissioners for the Examination of Surveyors" to be selected from the best practical surveyors of the state most distinguished for their scientific and

practical knowledge of surveying, one of whom shall be appointed to hold his office for two years, one for four years, and one for six years, respectively, from the first Monday of July, A. D. 1887 and until their successors shall be appointed and qualified. And during the month of January, A. D. 1889, and every two years thereafter, the Governor, by and with the consent of the senate, shall appoint one commissioner, to be selected from the most skillful and experienced of the licensed surveyors, as herein after provided for, to fill the place of the commissioner whose term of office shall expire on the first Monday of July thereafter. And it shall be the duty of said commissioners, or a majority of them, to meet at least once in Springfield and once in Chicago within the first year after the passage of this act, and at least once a year thereafter at some place to be by them designated, notice whereof shall be given for twenty days preceding the time of said meeting, in a newspaper published in the county where the said meeting is to be held, to all persons desirous of obtaining a license to survey, of the time and place of said meeting. It shall be the duty of the said commissioners, or a majority of them, to examine and pass upon the qualifications of all applicants for said license, and to certify to the Governor the names of such applicants as they may find to be thoroughly qualified in the theory and practice of surveying, and who shall have produced satisfactory proof of strict integrity and moral character; and thereupon it shall be the duty of the Governor to issue a commission, under seal of the state, to each of said applicants so certified to, licensing and empowering them, as surveyors, to survey in any and all parts of this state and to do and perform all acts in relation to surveying the same as county surveyors are now or may be hereafter authorized to do by the laws of this state.

SEC. 2. Each surveyor commissioned as aforesaid, before proceeding to survey, shall take and subscribe an oath, before some clerk of the circuit court or county court in this state, that he will in all things faithfully and impartially perform the duties of surveyor to the best of his skill and abilities, which oath shall be endorsed on his commission; and the said commission shall be entered of record in the recorder's office of each of the counties of this state in which said surveyor shall make surveys, and a certified copy of said record shall be evidence in all courts of law and equity, without producing or accounting for said original commission.

SEC. 3. Each licensed surveyor as aforesaid shall, before making a survey of any tract of land, provide himself with a copy of the government plats and field notes thereof, and with such other recorded evidence of survey as may be necessary to his purpose and shall make his survey in conformity thereto and to the acts of congress and to the statutes of Illinois governing the same, and he shall be authorized and required to administer to his chainmen and flagmen the necessary oath for the faithful and proper performance of their respective duties and he shall be empowered to administer and certify any oath required to be taken by commissioners for the assignment of dower or the partition of real estate or by any commissioner or viewer to mark, locate or re-locate any public highway or private road, and to take the evidence, and to incorporate the

same with his survey, of any person who may be able to identify any original government or other legally established corner or witness thereto or government line tree whenever such licensed surveyor may be in doubt as to its identity or verity.

SEC. 4. All chainmen, flagmen and other necessary hands in any survey shall be furnished by the person for whose benefit such surveying is done, and they shall be good and disinterested persons to be approved by such licensed surveyor.

SEC. 5. All surveys and proceedings had and done by said licensed surveyor under and by virtue of this act shall be held and taken to be *prima facie* correct and all plats and certificates thereof under the hand of said surveyor shall be received in evidence in all courts of law and equity in this state and be entitled to be entered of record in the recorder's office of the several counties thereof; but no such plat or certificate made by such licensed surveyor or by any county surveyor of any subdivision of land or any new street, highway or alley within any incorporated city or town shall be so recorded until it shall be first approved by the proper authoritities of said city or town.

SEC. 6. The circuit court of the county where any surveyor commissioned under the provisions of this act may survey shall have power to annul said commission upon satisfactory evidence being presented of the incompetency or misconduct of such surveyor, said surveyor having been notified to appear in his own defense, and upon such annulment and notice thereof from said court the Secretary of State shall cancel the same and mark the date of such canceling upon the records in his office.

SEC. 7. Each applicant for license under this act shall pay into the the hands of said commissioners the sum of twenty dollars as a fee. The commissioners shall pay from the fund so established all the expenses necessary to fully carry out this act including their own necessary expenses while actually engaged in the discharge of their duties. The said commissioners shall not allow to themselves any other compensation or emolument. Provided, that any candidate who may fail to pass an examination shall be entitled to a second examination not less than six months nor more than one year after such failure without further payment therefor.

SEC. 8. The said commissioners shall meet within thirty days after this act goes into effect and organize. They shall elect one of their number treasurer who shall make a bond of amount to be determined by the said commissioners to be approved by the Governor and file the same in the office of the Secretary of State And annually during the ten days preceding the first day of January the said commissioners shall make a report to the Governor of all acts performed by them and account for all funds placed in their hands.

DISCUSSION.

Mr. Burt.—Can the Surveyor if he is required as a witness demand fees for expert testimony?

Mr. Greeley.—That should be the case though this bill does not provide for it.

Mr. Burt.—I was recently called in a case requiring three days time and am desirous of knowing what I can obtain for my services.

Mr. Ela.—You can certainly demand expert's fees if you are required to go outside your county.

Mr. Burt.—In this particular case a party had driven the road commissioners off his premises who were locating a road thereon, and had brought suit against them for trespass.

Mr. Foster.—I think there is nothing that will require a surveyor to go onto the property of another without furnishing him proper protection.

Mr. Alkire.—I think the suggestion of Mr. Foster a good one. There is, I believe, a statute allowing railroad engineers to go onto the premises of another in the discharge of their duties and only be liable for actual damage done to the property.

Mr. Foster.—I had a bad bit of experience of that kind in Minnesota once. A man on whose property I was about to enter threatened my life with a loaded gun. I had him fined $300 though, which he readily paid.

Mr. Greeley.—There would be no objection certainly to incorporating such a clause as has been referred to in the bill.

THE SEPARATE *vs.* THE COMBINED SYSTEM OF DRAINAGE FOR CITIES.

By S. A. BULLARD, of Springfield.

I do not believe it to be my duty in presenting this paper to advocate either system of sewerage here spoken of, but to present such points in favor of both systems as they may possess, and to make a critical examination of the faults of both these systems. For certainly neither is faultless and neither so objectionable that it will not do the work required of it reasonably well.

The matters to be disposed of by sewers in cities arise from several sources, namely: storm water, the water which naturally falls on streets, sidewalks, house roofs and yards by rains and snows; subsoil water, the water in the soil of the streets that must be removed in whole or in part in order that the surface of the street may be made

to best subserve the uses for which it is constructed; water arising in the cellars of building that must be disposed of for sanitary reasons; the drainage from buildings as a result of their being used by human beings, such as that coming from bath rooms, sinks, wash bowls, laundries, water closets, factories, mills, water motors and so forth.

The combined system of sewerage seeks to carry off and dispose of the materials arising from these sources through a single system of channels or pipes; while the separate system disposes of storm water, subsoil water and cellar drains through one system of channels, and the drainage from human habitations through an entirely different one, thus having two conduits for carrying the refuse matters beneath the surface of the streets and alleys.

I shall attempt to make a comparison between these systems under several heads:—

Effectiveness of the work accomplished by each.
Sanitary results.
Cost of operation and repairs.
Economy of cost.
Agreement with the philosophy of growth of cities.

First, The work sought to be performed by any sewer or system of sewers is to rapidly and effectually dispose of the contents which flow into it without retaining any matter by absorption or other means so that foul or poisonous gases may be produced thereby.

The materials of which the sewer is constructed, the grade at which put in, the size of sewer and amount of liquid usually passing through determine almost entirely the efficiency with which it does its work. Salt-glazed sewer pipe with cement joints is smooth and when properly laid in the sewer affords no retention of sewage by absorption and very little by mechanical means. Brick is absorbent and will retain animal matters in its substance when in solution. If well covered with cement on the inside, the same being trowelled firmly and smoothly, the amount of absorption is immaterial and also the amount of matters held mechanically. Stone is little absorbent, but if not cut smooth and well laid—which will make great additional expense—the retention by mechanical means will be comparatively great.

The materials commonly used for the construction of sewers by the combined system are vitrified pipe, brick and stone—sewer pipe where the size is below twenty-four inches in diameter, brick from two feet to six or eight feet in diameter, and stone and brick for larger sewers. The invert of brick sewers if plastered with cement and smoothly troweled over acts very well. The invert alone need be cemented as that is the only part which comes in contact with animal sewage. When the sewer is more than one-fourth full, which is only on entrance of storm water, the animal sewage is so diluted as not to be offensive and is swept entirely away. Stone being used only in the larger sewers which always carry considerable sewage are by the flow generally kept clean and in good condition.

The materials used exclusively for the separate system are vitrified sewer pipe for the sewers carrying animal matters, and brick and stone for the sewers carrying storm water and so forth. So far as the results are concerned both systems seem to possess equal facilities for accomplishing the objects of their construction.

Second. The value of any system of sewerage should be decided almost wholly from sanitary considerations. If the refuse matters to be carried off are for any reason kept from passing immediately away, thus enabling gases to rise and float out into the atmosphere or fill all the pipes leading to the sewer, then the system cannot be good. It must not be understood, however, that any sewer, however perfect, produces absolutely no sewer gas. As a general rule it may be promulgated that all sewers produce sewer gas, the only question being which system produces the least and how can that minimum amount be kept from the presence of living beings except in a very diluted state.

In the small sewers of the separate system vitrified pipe is generally used, which is the best material for sewerage purposes; the combined system uses sewer pipe in the smallest sewers and brick and stone in the larger ones. Brick being less desirable than pipe would seem to give the preference to the separate system.

I take this occasion to remark that the question of the amount of sewer gas evolved in sewers is secondary to the question of ventilation of sewers and the construction and connections of house drains. It is a fact that no sanitary engineer ought to have any pressure of gas in his sewers. Proper ventilation will positively relieve pressure. Sewer gas we cannot suppress, but to allow it to be thrust into our lungs in a dangerous degree of concentration is criminal; especially so since the science of pneumatics so materially comes to the sanitarian's assistance. A further discussion of this would certainly be beneficial but the limits of this paper will not permit.

Third, The perfect sewer is one that never needs repairs and would work automatically or by natural law and require no attention or expense to maintain. Repairs and maintenance should have due weight in adopting or executing any system of drainage. If the first cost of the plant were all in conducting the affairs of a great mill, that were a trifle, but the continual calls to settle coal bills and water tax draw away the earnings of a prosperous company. Much the advantage has the mill situated on a choice mill race of a living stream where by natural means alone the power is obtained to drive the ponderous machinery. The Bridgeport pumping works of Chicago are a dead expense forever, to abolish which the city would be justified in expending a sum, the annual interest of which would far exceed the annual expense of maintenance of the pumps. There are only two reasons that would justify a city in continuing such a burden—the impossibility of having it done by natural means, and the poverty of the people interested.

Repairs of sewers are usually met in the replacement of manholes and covers and street inlets and occasionally of the material of the sewer itself. The cost of maintenance arises from pumping works, flushing and cleansing and sewage disposal.

The cost of repairs would not differ in amount very much in the systems under consideration. The cost of maintenance, however, will differ greatly if there is much pumping of the sewage to be done, for in the combined system the whole amount of flood and subsoil water is added to that of the sewage of house drains, which is all that would be required to be pumped usually in the sewers of the separate system. A system of flushing and cleansing must usually be adopted in the separate system in order to insure good service. That is a continual expense and should be sought to be avoided. The combined system is not subjected to that expense if there is a reasonable amount of fall to the sewers.

If the sewers have for an outlet a large flowing stream or lake or a sea with tides, the question of sewage disposal does not enter into the plans for a sewer system, but if for any reason no proper outlet may be found then the question enters largely into the problem. In most American cities the question is not met with, but in many of the cities of Europe it is equal with other questions affecting the health not only of the city to be sewered but of thickly populated districts in the vicinity. The less the amount of sewage the more easily disposed of, and an advantage is found in the small amounts of animal sewage carried by the separate system. In a system of sewers the less attention and machinery required to keep it performing its work the better. That system is superior which will dispose rapidly of matters carried into it by natural means and which keeps itself clean, requiring no flush tanks to aid in doing its work. Everything connected therewith requiring the attention of any one to see that it works properly doubles the possibility of failure and adds a burden which though not excessive is still too great to be borne continually.

Fourth, The combined system seeks to carry off the storm water, subsoil and cellar water and house drainage in one channel. To do this the channel must be large enough to dispose of these during excessive floods, and of such depth as to admit these without at any time backing sewage through any of the connections. The separate system seeks to dispose of storm, subsoil and cellar water through one channel and the house drainage through another. Since the house drainage forms but a small portion of the whole sewage the separate conduit for its removal may be comparatively small. The conduit for the removal of the clean waters of the separate system will be as large as the single conduit of the combined system and must be of the same depth, for the cellar waters are carried into it. The small conduit for the removal of house sewage will have necessarily considerable depth also on account of water closets in cellars having to be provided for. This condition then results. The sepa-

rate system for the proper and usual sewerage of a city requires a sewer of size and depth of that required by the combined system, and in addition a separate conduit, smaller but the same depth, for the disposal of animal matters. Hence the cost of the separate system would be much greater than of the combined, if the same work is sought to be performed. The additional cost of constructing the separate system, however, is sought to be lessened by leaving off a portion of the sewer for carrying the flood water, subsoil and cellar water as not necessary to the drainage of the city. This is usually done wholly or in part by engineers who advocate the separate system. It is a great oversight, however, for it is a necessity for the healthfulness of a house that the basement and cellar be dry and well drained. The drainage of the street may be carried off for several blocks very often, thus saving the cost of underground water-courses, but the cellars cannot be made dry without a thorough outlet at a depth lower than the bottom of the cellar. Economy would largely favor the construction of the combined system.

Fifth. There is a method in nature, the key to which if found will better enable us to discern what accords and what does not, with the reasons therefor, and the results therefrom. It does not necessarily follow that that which conforms to natural law is the best at all times to follow. As well might the child say that by the laws of nature his face and hands became soiled and therefore he would put himself in accord with nature by letting them go unwashed. The history of progress is much the history of the subjection of nature. Thus the forest is laid low and made to fence the fields against the ravages of wild animals which naturally would have a right there. The rock from the quarry is removed and made to do service in man's protection and happiness by being built into forts and houses. But amid all this seeming opposition, natural law is still positive and powerful. The felled tree is carried to the earth by gravity and the parts separated by the saw have simply submitted to the superior power of man to manipulate the laws of nature to his own advancement. The growth of cities is accomplished in a natural way; by the exercise of the superiority of man's mind over matter according to natural laws. A village site is chosen according to the natural lay of the land. The beautiful sloping bank of a large stream may be chosen with here and there a small run which conducts the water from above at the flood seasons to the stream below. Houses are built on the highest points of ground near the runs, and water from house conductors, waste from wells and cisterns and stables run into it. For convenience to travel, culverts are built where the streets cross the runs. As land for building purposes grows scarce houses are erected nearer the runs, and in order to make it pleasant for habitation and to reduce the lawn to more symmetry the culvert in the street is continued through private property to the next street crossing, and all the wastes from the houses, the flood water, the subsoil

and the cellar are carried off through the natural water-course. Along the line of the streets are cut gutters and the flood water which usually ran directly into the run is intercepted and turned down these gutters to be taken into the run at the culvert. The street gutter washes, and a way is sought which will enable the authorities to take the water from the street at the intersecting street above and thus relieve the gutters from the action of the water. Houses along the street can not be directly drained into the run below and can not be allowed to drain indiscriminately into the gutters. It is decided to build a water-course along the line of the street running into the culvert below with capacity and depth to take the surface or storm water from the street, subsoil water, cellar drain, house and overflow drains and so forth, and a system of sewers is inaugurated which when continued will satisfy all the drainage and sanitary needs of a great and prosperous city.

Cities are not planned out and constructed like the town of Pullman, else like it an arbitrary system of sewerage could be planned in harmony therewith and be made to conform to the structures, formation and needs of the different districts comprising the city; but cities are the result of a planting and a growth, and often no more can be told when a village is started what the result will be than what will be the product of an acorn when laid in the earth—it may be a grand and mighty oak, or, stunted by some external or natural means, it may be small and bushy with neither beauty nor grandeur and fit only for the support of lichens and leaves.

Along with the growth of cities is the growth of those things which distinguish the town from the city and the village from the town and the hamlet from the village.

Pedagogues have a method which they claim to be superior to all other for teaching children called the natural method. Cities seem to persist in growing by a natural method, and is it not the part of wisdom and economy to plan and assist in the growth by providing for the health and happiness of their inhabitants by planning and forming the means of disposing of the sewage in a natural manner rather than in an artificial or empirical one?

DISCUSSION.

Mr. Mead.—What method would you recommend for the ventilation of sewers?

Mr. Bullard.—Ventilate the sewer through the manhole covers and direct inlets at the street corners. Every house drain should be trapped from the sewer and ventilated thoroughly above the trap to the roof the house, every trap in the house having a ventilating pipe connected with the main one.

Mr. Mead.—In Rockford there is a general opinion against ven-

tilating the house connections. They use mainly the ventilating manholes at intersections of streets.

Mr. Foster.—I would recommend, as is used in the town of Lake, Cook county, the placing of ventilating manholes every 250 feet on main sewers and the use of traps just inside the curb in every private drain with a ventilator to the surface.

Mr. Foster related that while engineer of the town of Lake the town board in the face of his remonstrance had a sewer through one of the streets of the Union stock yards constructed with the bottom of the sewer two and one-half feet below the surface of the water in the river at the outlet, intending to keep the sewer clean by a system of cleansing. The result was that before a year three men sent in for the purpose of cleansing the sewer lost their lives, and today the idea of cleansing is abandoned and the sewer stands half full of putrefying matter from the slaughter houses.

TOPOGRAPICAL SURVEYS AND RECORDS FOR DRAINAGE PURPOSES.

BY C. G. ELLIOTT, OF TONICA.

This branch of engineering differs from others in many respects. The manner of obtaining data and general methods employed are not unlike those pertaining to other departments of engineering work. Drainage surveys involve the collection and representation of such facts relating to the surface of the land, its soil and subsoil, its vegetation, to the water courses, rainfall, and climate of the vicinity, as will be of service in determining upon and carrying out a plan for the profitable drainage of the land so examined. It is a branch of work that comes within the special province of the drainage engineer, and it must be done with greater or less thoroughness before he can plan a drainage project with any assurance that it will accomplish the desired work when carried out.

In the absence of any treatise on topographical drainage surveys, I shall attempt to shape this paper from my own experience and practice. It is quite probable that others of the profession will make well-deserved criticisms upon it, and suggest improved methods.

The completeness of a drainage survey must be measured by the time and money that can be devoted to it, and by the thoroughness

of the proposed work for which the survey is made. There should be an adaptation of these factors to the result aimed at. The engineer must first understand what data and information are required, and then make his plans to obtain it in the most systematic and expeditious manner possible; otherwise he will fritter away his time and energy upon matters that do not pertain to the case in hand.

A survey may be required of a field, farm, district, township, or county, yet in all cases the work must be so conducted as to cover the points that will be required, and as much more as can be done within the limits of the time and expense. Every thorough-going engineer takes pride in making his work as complete as possible even at the expense of doing work which he may think is a little beyond the necessities of the case.

The Outline Survey.—The outline survey or reconnoissance consists of making a personal examination of the ground with reference to its general features or geography, using for this purpose any surveys or maps that can be obtained and information that can be gathered from residents and others who are acquainted with the land. It should include an examination of the water-courses and ditches. where their source is, and where they discharge. The kind of soil may often be read by the character of the vegetation which it produces. Its object is to determine the practicability of some proposed drainage scheme, or to plan for a more complete survey of the field or tract. If it is simply a field, a few levels may be taken, the watersheds determined, and the engineer can at once make his plans and proceed with the location work. This is the simplest form of outline survey and is applicable only to fields whose drainage limits and slopes are easily determined.

If a drainage survey is to be made of a farm or district, there are two methods that may be used:

1. *With boundary line base.* Having the boundaries of the tract, its subdivisions, and all the geography obtainable sketched upon the field book, go to the supposed lowest part of the tract and establish a bench from which to level. Run a line of levels on or near the boundary of the tract, taking elevations of the highest and lowest points, important ditches, ponds, flats, etc. A plug should be set at each point where readings are taken and its position marked by a guide upon which should be placed its consecutive number from the initial point. All elevations should be referred to the initial bench. which for convenience may be recorded 100. Distances can be ascertained quite closely by pacing, and in this way the position of points and objects can be transferred to the map of the field-book. As this boundary line work proceeds, interior points can be taken, when thought desirable, by long sights.

After passing around the tract in this way and closing on the initial bench, interior cross lines may be run with sufficient frequency to locate all necessary topographical features. I have found that the

note-book sketch made in the field and connected with the notes is of great value in this kind of work. It may be made in sections, or one page of the book may be sufficient to give the whole plat.

During this operation the engineer should keep his eyes open to every peculiarity of the land over which he passes. He should keep running notes in his mind and make entries in his book of observations that may be of use to him in making up his topography. Is there a place unaccountably wet, let him get data enough to enable him to solve the case. If ditches of any kind exist, observe how they affect the soil through which they pass.

For a survey of this kind the assistant should be efficient and expeditious, thus leaving the man at the instrument free to give his entire attention to his proper work without being harassed by a blundering rodman. Care should be taken to use every check possible to insure correct elevations, not only for the sake of good work, but also to give the engineer confidence in himself. A mistake will often tire an engineer as much as a day's work.

2. *Water-course base.* A second method especially applicable to district work is to use the main water-course as a base and refer all other lines to it. In this case the line should be measured, stakes set at the angles, and levels taken. Ordinates may be run from this line in such directions and to such points as the judgment of the engineer may dictate. The object sought is the same in either case of procedure, viz: to get the course and slope of the natural depressions, to find the water-shed lines and the area of the drainage basins.

Record of the Work.—The engineer now wishes to put this work on record so that he can plan future location surveys intelligently or represent the capabilities of the tract plainly to others, which latter consideration is often quite important. For this purpose the plat should be transferred from the field-book to a sheet drawn to a scale sufficiently large to allow the entry of all necessary items. Record the elevations directly upon the map. Indicate water-courses, ponds, willows, etc., by both conventional signs and descriptive words. Sketch in dividing lines on water-sheds, and indicate surface slopes by arrows. Designate each basin which has its outlet at one point as a drainage section and name it by assigning to it a letter of the alphabet.

We now have a geography of the tract which shows its natural drainage facilities. The elevation numbers show the actual fall from one point to another. The engineer can now compute quite closely the area of each drainage section. The topography is plain to every one who may have occasion to examine the map. It fits the ground so that most of the points can be re-located from the map by their relations to natural objects and established features. An approximate estimate of the cost of drainage could be made from this map and survey, yet for this purpose we should proceed farther and make an estimate survey.

Estimate Survey.—This consists of locating the course and

length of the main lines in each section. The engineer can locate all drain lines more satisfactorily by personally walking over the ground, than by directing an assistant, so that he will find it advantageous to flag out the courses of important drains himself. The tangents should be measured and plugs set at angles and at junctions of proposed branch lines with others. Take the bearings of tangents with the compass and the elevations of plugs with the level. Make a record of this in the field-book, and sketch the lines on the map. For this general work I find the combined transit and level, with compass and vertical arc, very convenient and serviceable. The objection often made that good leveling cannot be done with such an instrument, I do not find sustained by my own experience.

Having the location and length of all leading lines and the area of the drainage sections, the engineer can decide upon the size and cost of mains, whether they be open channels or large tiles. The estimate of lateral drainage can be made from data furnished from these two surveys, provided the work is platted to a scale.

While it may seem desirable to have the stakes which have been set on the estimate survey preserved for future use, it is not often practicable to do so, except perhaps the initial point and bench mark for each section. In location the lines must be retraced from data recorded upon the map. Each drain line as run out should be designated by a name, number, or letter, which should distinguish it from all others, and by which it should be known in all descriptions pertaining to the work.

Estimate Record.—The size and kind of ditches and estimated cost should be put in tabular form to accompany the map, the nomenclature used in both being the same. The size of open channels may be described by giving the bottom width, which I am accustomed to call the base, and the vertical depth, the side slopes being uniform. In preparing this work it should be remembered that it must be so done as to be plain to the land-owner or other non-professional who may be interested in, or who for any reason may have occasion to examine the work. System, simplicity and plainness should be the leading characteristics of the engineer's maps and records.

Subsoil Topography.—Another necessary investigation connected with drainage topography is the relation of soil to subsoil and the character of both. The engineer requires a knowledge of these as to their physical structure and drainage properties, their behavior when dry and when saturated with water, their inherent fertility and vegetation adapted to them. Some wet soils are not worth draining. Some require more drainage than others to bring them to a given standard of perfection. The subsoil has a topography as well as the surface which must always be taken into account. For this purpose cross sections should be made at various points, especially where the surface indications suggest something different from the prevailing subsoil features. The location of such peculiarities should be indi-

cated on the map, and described with the help of cross-section drawings, if they are of sufficient importance to merit it.

Economic Drainage Topography.—Another department of this work is its treatment with reference to its economic features. No sooner has a survey been made for drainage purposes than the engineer is asked: "Will it pay to drain this land? What will it cost per acre? What profit will this investment pay per annum?" So that the engineer must not only be acquainted with the kind of work and outlay that will be required, but also with the probable income that will result to the investor. In other engineering projects there is usually a division of the work, one doing one part of the work and another another part, but the drainage engineer must personally perform all of the duties before named, and also be prepared to supplement his report with a discussion of the economic and financial aspects of the case. It is in fact the end for which the work has been done, and the engineer who is not able to handle this part of the subject can not meet the requirement often justly made of him. This may be a digression from the subject proper, but it is so closely allied to it that it demands attention.

It will doubtless occur to many that the work as it has been outlined lacks that elaborate completeness that is generally acknowledged to be necessary in a topographical survey. It should be remembered, however, that in this kind of work the survey is not considered to be completed until the location work is done.

Let us notice the steps. First, the outline survey from which is determined whether or not it is possible or desirable to proceed with drainage work. If for any reason it is not desirable, no farther investigations are necessary. Second, the estimate survey, made for the purpose of arriving at the approximate cost of proposed drainage when done with various degrees of thoroughness. Should nothing farther be done towards executing the work, no labor has been lost; but if the drains should be located and constructed, all of the work previously done will be supplemented by the notes necessitated by the running out, measurement and leveling of the principal and lateral lines of drains. When this is done the engineer will have data for a topographical map which would be complete in all of its details. The whole work has been accomplished by steps, each one of which was necessary for the immediate object in view.

TOPOGRAPHICAL SURVEY FOR THE DRAINAGE OF THE RED RIVER VALLEY IN MINNESOTA.

This work being of more than ordinary magnitude and coming properly under the topic of this paper, I will give a brief description of the methods used in its prosecution.

The valley of the Red River of the North on the Minnesota side for a distance of fifteen miles or more out from the stream, is a plane of prairie land showing to the eye no fall whatever. Small streams, called rivers, rise in the elevated portions of the eastern part

of the valley and flow towards the Red River, generally in a northwesterly course. Some of these streams instead of discharging directly into the Red River empty upon the level prairie, thus forming vast wastes. These same conditions exist with reference to the interior runs or creeks. Instead of discharging into some large streams they discharge upon the more level land. The object of the survey was to ascertain all of these facts, find out the actual condition of the land and to devise a plan for the drainage of this belt of country so rich in wheat producing elements.

A survey of the tract, by using the streams as bases or centers of operations, seemed impractical for the reason that there was no valley slope toward the streams; on the contrary the land was usually higher near the streams than at a distance from them at right angles to their courses. The plan of work finally determined upon was to run lines of levels parallel to each other east and west, to and from the Red River, using the government survey section lines to define the courses, and the section and quarter-section corners to locate level points. We then made tracings of the plats of the government survey which are on record in the Land Offices of the several districts, and so obtained all of the topographical features that were recorded by the government surveyors. These plats were drawn to a scale of two inches per mile, and were used for field maps.

Our datum was that of the Railroad Company, which they had obtained from the U. S. Government Survey of the Red River and is approximately, at least, sea-level. By using the bench-marks of both River Survey and the Railroad, we were enabled to preserve a common datum throughout the work.

The field work was done entirely by parties which lived in camp. Each party consisted of four levelers, four rodmen, one teamster and team, and one cook. One leveler was placed in charge of the party, whose duty it was to direct the movements of the party, keep up the field maps, and see that all books and field work checked correctly. He was expected to do this in addition to carrying his own line.

The manner of procedure was about as follows: Having obtained a reliable bench-mark at which to begin, a base line is run quite carefully north or south on a section line, and each leveler starts from a point that is established on this line and proceeds to run the line previously assigned to him. Each leveler runs on a section line, so that the men are one mile apart, and the party covers a strip of territory four miles wide. The camp has been instructed to move forward a day's run and to pitch as near the middle of the four-mile strip as practicable. In the meantime the levelers and rodmen. being provided with lunches and canteens of water, proceed, taking one-eight mile sights, making four settings to the mile. Any sloughs or water-courses on or near the line are noted and elevations taken of the beds of their channels. Equal fore-sights and back-sights are preserved, by both rodman and instrument man counting their paces from station to station, the correctness of which they can

determine by checking on the section and quarter-section corners. Each man has been instructed how far to run. This limit being reached, the men on outside lines check on plugs left by men on the two interior lines, and the inside men check towards camp. This closes the day's run. The leveler in charge now calls for check points and compares them. Each man is expected to balance his book before he reports check points. The variation from the mean which was allowed on a seven-mile run was three-tenths of a foot. If any one fell outside of this his standing point for the next day must be corrected to the mean elevation of the other three results, unless there appeared to be a serious error, when the whole line was thrown out or re-run. The leveler in charge now records upon the field-map the elevations taken during the day, sketches in whatever topography has been obtained, etc. The next morning the men take up their respective lines, and the camp pulls up stakes and moves to the end of another day's run.

An ordinary day's run was six miles and one mile to check. The state of the weather, the atmosphere, and the kind of ground had much to do with the speed that it was possible to make. Twenty-two-inch Wye levels were used with one or two exceptions. Refraction and high winds were the principal causes of error, though, of course, the instrument and the skill of the one using it figured quite largely in failures to check well.

This general plan of field work was pursued during the entire work. A portion of the valley about 170 miles long and from 12 to 20 miles wide was surveyed by three parties in three months time. Permanent maps have been made from the field maps. The elevations have been recorded upon them direct at section and quarter-section corners, and at other desirable and useful points. From the data thus recorded upon these maps main ditches have been projected, water-shed lines indicated, size of ditches computed and their cost estimated.

This very briefly outlines the general methods used by the writer in this work. I believe that the plan of recording elevation numbers directly upon the map is more serviceable in the planning of drainage works than any other method of representing topography, and is applicable to all lands requiring surveys for this purpose.

DISCUSSION.

Mr. Braucher.—How near the limit of three-tenths did the work usually come?

Mr. Elliott.—Generally the work checked to one or two tenths, not often more than that.

Mr. Mead.—The cross sections mentioned to show the subsoil, how were they taken?

Mr. Elliott.—By boring or outcroppings, or by digging wells.

Mr. Bell.—What is the nature of the soil in the valley?

Mr. Elliott.—Loam and clay, with some sand in places, and in some places hard pan.

Mr. McClanahan.—What success have you had in draining hard pan?

Mr. Elliott.—I have had very good success in draining lands with hard pan. We have always to take into consideration the nature of the soils to be drained and to make the plans accordingly.

Mr. Baker.—Mr. Elliott said he would write the elevations on the map. Why does he prefer that to contour lines?

Mr. Elliott.—The map is generally used to give certain information to persons who are unfamiliar with engineering terms and engineer's signs. By this method they understand the map better without explanation.

Mr. Braucher —In underdrainage we had an unusual experience some time ago. In draining a large tract we had part of the tiles laid, when in the month of June there came four great rains causing the water to stand on the ground over the tiles to some depth. People complained that the tiles were not large enough. Later experience showed, however, that it was not so much the size of the tiles as the difficulty of the water getting into the tiles. The soil in this case was after each rain found to be covered with a thin deposit of clay almost impervious to water. I also had a case where a tile ran through a basin and emptied into a well near the enter of the basin. The water stood in the basin over the tile, but was kept from the well by a small circle of earth thrown about it. I went to the well, expecting to find the water in the well the same height as that in the basin, and was surprised to find that the tile entering the well was only half covered.

Mr. Stanford.—How deep were your tiles in the ground?

Mr. Braucher.—From three feet to four and one-half and five feet.

Mr. Stanford.—Did you find the tile in the first instance you mention to be running full?

Mr. Braucher.—No, sir.

Mr. Stanford.——I once laid a tile from a pond into a well to furnish water in dry weather. The person for whom it was done was indignant that the pond did not give up its water to the well. After one year no trouble was met with. Most of the country near us—Livingston county—has a hard subsoil. I have known tile to

run only half full, when if the tile were ventilated the amount of water delivered would be almost doubled.

Mr. Gifford.—At what point do you ventilate?

Mr. Stanford.—At or near the upper end.

Mr. Braucher.—I have a theory in regard to ventilating. I think it is not an advantage, but a disadvantage to ventilate tile drains. By having no place for the admission of air the tile forms a suction and draws like a pump till the water surrounding the tile is reduced so low that air is allowed to enter and then the water enters the tile by pressure alone.

Mr. McClanahan.—I experimented with a line of 15-inch and 12-inch tile $1\frac{1}{4}$ miles in length. I put in three equidistant ventilators which extendod three feet above the surface. I had several laterals running into the main on which were ventilators. I tested the flow while the ventilators were both closed and open and found that they had no effect upon the amount of flow. I remember another line of tile about the same length as the one mentioned, where it was observed to flow at its full capacity though there were no ventilators about it.

Mr. Braucher.—Many laterals are good and add to the working power of the main tile. My idea of suction where the tile is entirely surrounded with water was derived from a water wheel in a mill near where I was raised. The outlet of the tile must be under water in order to let no air pass through from below.

Mr. McClanahan.—I put my tile pretty deep, not less than $3\frac{1}{2}$ to 5 feet. The deepest cut I ever made was eleven feet. The average depth of some work I did lately for Mr. Tubbs, of Monmouth, was 5.34 feet. These tiles draw the water well for three hundred feet each side of the line. I have found the most essential points to be, first, size of tile, and second, grade. Get a good outlet, though. I have run tile at one inch to one hundred feet. Near Minneapolis, Iowa, I was called to relay a tile that had failed. The subsoil was hard pan. The tile had been laid three feet in depth but gave no satisfaction. I put the tile five feet deep and in filling the trench I filled with top earth and kept the hard pan out. It has done remarkably well.

Mr. Braucher.—What is your minimum grade?

Mr. McClanahan.—I would run a few hundred feet of the lowest tiles level if it were necessary to get a fair fall in the upper end.

Mr. Foster.—I want to ask what I consider a practical question: What size pipe shall I put in? Is there any method or fixed fact by which I may estimate the size of pipe from the acreage?

Mr. Elliott.—We have some formulas, but they do not answer successfully. They are mostly based on hydraulics. That question is yet an undetermined one. The nature of the soil and many other things enter into it, and it can only be determined by experiment.

Mr. Mead.—I would ask if Mr. Foster has such a formula?

Mr. Foster.—I have no formula to fit all sorts of things. The nature of the soil and the contour vary the application. I know of no other way to do but to contour the ground, consider the nature of the soil and then guess at the size of the pipe to put it. A comparison with the amount of flow in open ditches is perhaps the best way to check up your judgments.

Mr. Mead.—I did not understand Mr. Elliott's reasons for not using contour lines. It seems to me contour lines would show much better than figures. The figures will give fractional heights, but I see no other advantage.

Mr. Elliott.—The work of getting the data necessary to establish contour lines adds a large expense to the survey. We enter upon drainage by steps. We do some work to see if the result will justify the expense of more, and yet we do not want to lose the work already done. We do not care for comparisons between all points. What we want to know is the lowest and highest points. It is cheaper and more intelligible.

Mr. Braucher.—An examination of the ground by the engineer will better enable him to decide where drains should be laid than by contour lines on his maps in his office. In figuring on capacity, do not provide for floods; you may overreach the means of the proprietor. Put in pipe large enough to carry ordinary flow and leave surface ditches for excess of flow in floods.

Mr. Talbot.—The question of contours or no contours depends upon the make-up of the engineer. I have seen railroad engineers who could tell, by the eye alone, just where the line should be run. To these, contours would be of no assistance. After he has been over the ground the contour lines will enable the engineer better to see and take in the whole field, and to locate the course and decide upon the size of the drain. The idea of greatly increased cost is based upon methods that need not be used in this case. With the levels given in the survey referred to, a fairly skillful topographer can

sketch in all the necessary contours by the eye; or the engineer in charge could do it in addition to his other duties. Of course, previous practice and experience is necessary.

Mr. Clark.—I believe in contour lines. I do not think there is much added expense. But to the engineer the contour is much more intelligible.

Mr. Elliott.—What is the use of contours if you do not locate them properly? Why not give total slope with direction? A very few points are usually all we need. The cost I find to be considerable to get all the information necessary for contours.

Mr. Mead.—Even if the contour lines are guessed in I think it better. A scientific guess is pretty good. Two years ago on the geological survey in the Chippewa valley, in Wisconsin, we took cross sections of the valley, the river and the inclinations. The contour lines sketched in showed better than a few points actually known.

SOME HINTS ON FIELD WORK IN DRAINAGE ENGINEERING.

By A. H. BELL, of Bloomington.

It was suggested to me by your worthy Executive Secretary, that a few items relative to the details of field work in drainage engineering might prove of interest to members of the association, hence the following:

I chanced one day in the past to pick up one of those volumes intended for the culinary department of the household, and observed upon its pages a recipe for cooking that subject of the genus lepus known as the rabbit. The preliminary remarks were what impressed my mind. "First catch the rabbit." So it might be suggested in this case: First get the job! However, this suggestion is probably only applicable to amateurs; as the improvement of land by drainage, the reclaiming of vast territories of swamp land, and the advancement of science in any direction is so dependent upon, and intimately connected with the profession of the Engineer and Surveyor, that he who has become proficient in his profession, and possesses a degree of moral worth, energy and ambition need experience no

obstacle in the way of finding enough work to call his services into action. True it is, some men display more tact and skill in securing practice in their profession, than others of equal and often superior ability, but this is the case in every line of business, whether mercantile or professional. In drainage work the engineer has to deal largely with farmers. They are on general principles a matter-of-fact class, a practical order of beings, moving along in the even tenor of their way, not quick to grasp at theoretical or scientific points and to whom seeing is believing. To obtain their confidence (which is essential to the engineer,) it is not desirable to be very scientific in the explanation of professional points.

I would not attempt to convince a Drainage Commissioner that the angle of incidence is equal to the angle of reflection, or that the angles at the base of an isosceles triangle are equal, however apparent it may be. Life is too short. Moreover he would probably only query in his mind what that had to do with the price of potatoes in the spring and question as to your rationality.

Nevertheless the Drainage Commissioner and farmer are about as good and genial subjects to practice for as the engineer will come in contact with. My connection with them has always been pleasant and satisfactory, finding them universally a sociable and agreeable class to serve. They sometimes exhibit symptoms of alarm when told that an engineer's services are worth *at least* $5.00 a day. This sounds to them like highway robbery, but when reminded of the fact that the competent surveyor must spend years of his life in hard study, sit up at nights and watch the meanderings of the celestial bodies, and expend what financial resources he has, (if he happens to have any),—in view of all these facts the average farmer will generally acquiesce in the belief that the compensation is reasonable at least.

In the case of an organized drainage district, a map of the territory embraced is about the first requisite. The nearer it approaches a complete topographical survey, the more serviceable it will be. It should be drawn upon good muslin-mounted paper, and on a scale large enough to plat the meanderings of all ditches without inconvenience. Should the district be large, this plat could be made in two, three, or four parts as may seem most desirable to secure the proper scale. Upon this map the results of all surveys should be detailed as nearly as possible as they progress. The best time to make an intelligent plat of the field work is immediately after the return from the field.

This plat of the district should be neatly headed, divided into sections, quarter-sections and 40 acre tracts with lines of different colors. The drainage law of this state requires the land to be classified in 40 acre tracts for assessment purposes, hence the necessity for such a subdivision. Upon each tract should be placed the name of the owner, its relative classification number, and final assessment when the same may be determined. These figures should be put on

only with pencil, to be inked when judgment has been confirmed by the court and all objections overruled.

All the topographical information that it is possible to place upon this map will be found to be exceedingly valuable to the engineer, the commissioner, and the district at large. The general nature and condition of the soil, and slope of the land should be noted on each 40 acre tract by some of the conventional signs or colors. The location of all public highways, houses, prominent bridges, tracts of timber, ponds, or other landmarks will be found of much service for future reference.

It is not necessary to observe any great degree of accuracy in this topographical work: stadia measurements and in many cases the eye alone are amply sufficient. A large proportion of the field notes for this class of work can be obtained while making surveys and locating the lines of the proposed ditches.

All drainage districts meet with more or less litigation in the courts, and the engineer with his plat constitutes a factor of vital importance to the Drainage Commission before this tribunal of justice. It would be well to bear this point in mind during all field operations; notes should be as complete and systematic and explicit as possible in order that they may be relied upon for information on short notice. Some knowledge of the drainage laws of the state will be found of much service to the engineer who practices in this capacity. Those who are elected as Drainage Commissioners are generally farmers, who have given but little thought or study to the drainage acts; hence the engineer can give many valuable suggestions and render his services all the more valuable by being posted in this direction.

For topographical notes a book of blank sectional diagrams about 8 inches square will be found very serviceable. The diagrams may represent sections, ¼ sections or 40-acre tracts as desired. The instrument most used in my practice in this class of work is an engineer's transit with extra long and sensitive level bubble. It has given very satisfactory results as a combination instrument for both leveling and transit work. It was manufactured by the firm now known as Heer & Seelig, of Chicago. There is a great advantage in being able to note the course and distances and levels of a ditch or line of tile at the same time. The self-reading rod is by far the most serviceable in drainage work. My own is of home make, is ten feet long, graduated to feet, tenths and hundredth. A target is used in connection with the rod for taking readings at long distances in case of change. This rod is in two sections (5 feet each) and is fastened together by means of a wooden rib at the back three feet long and one-tenth of a foot wide, permanently screwed to one-half of the rod. while two or three screws hold the other half in place. The steel tape (100 feet) is preferable to the chain in this practice. I make my flag pole as follows: Take a good jointed bamboo fishing pole, paint each alternate foot red and white, fit a well shaped and pointed iron pin

to the large end of the pole, and a red flag fastened to the small end will make it complete. This pole being of cane is light, the principal weight being at the ground point, and is easily thrust into the ground. Being jointed it is convenient for carrying, and can be used as a short or long pole as desired by using one or more sections of the rod.

There is one question upon which probably every engineer who has occasion to testify in court, where the drainage of land is in controversy, will be expected to give his opinion, so I herewith submit mine: The question is: What is the result or effect on the land of a deep open ditch, and how far on each side of its banks will it effect drainage for the adjoining territory, the supposition being, of course, that the ditch is in all respects of sufficient capacity to deliver its maximum supply. It has been but a short time since I heard the testimony on this subject of an engineer of some prominence, but of no experience. The testimony was given before a jury and was to the effect "that the ditch 7 to 8 feet deep, with heavy grade, only furnished an outlet for tile, and did not of itself materially aid in the drainage of the land." This idea struck me as being an antiquated chestnut. Experience has demonstrated beyond any possibility of doubt in this and adjoining counties that land can be effectually drained by an open ditch, and that some of the most impregnable swamps in the state have been entirely redeemed for agricultural purposes through the medium of the dredge boat in constructing an open ditch of sufficient capacity to procure underground drainage. The laying of tile no doubt would be beneficial as a measure to expedite and facilitate the flow of water through the soil to the main ditch. However, recent experience has plainly proved that very little necessity exists for the use of tile in the immediate vicinity of dredge boat ditches cut from 7 to 10 feet deep and sufficiently large in other respects.

Just how far an open ditch will drain or effect the drainage of the land on each side of its banks is a difficult matter to determine.

My opinion is, the land is more or less drained so far as the slope of the land tends toward the ditch on either side, and should you take a map of the ditch and territory embraced within its water-shed and color it, having the deepest color at the ditch and gradually shaded out to the extreme limits of the water-shed where the color would be imperceptible, you would have a diagram representing the action of an open ditch.

DISCUSSION.

Mr. Burt.—Is it true that the deeper the ditch the better? What is the the proper depth?

Mr. Braucher—Four or five feet.

Mr. Burt.—Is it true, barring the cost, that that depth is better?

Mr. McClanahan.—The subsoil is better for carrying water than the surface soil. I think the deeper the better.

Mr. Stanford.—I have been called on to plan a drain where the subsoil was impervious to water. I put the tile three deep. In case of a bed of gravelly subsoil I think it is best to lay the tile only a few inches below the bottom of the bed.

Mr. Bell.—On a question of much interest I should like to hear from Mr. McGillis, who has had charge of a steam ditching dredge for some time. It is in regard to the distance that drains will affect the height of water in the soil.

Mr. McGillis.—We were once running our ditcher cutting a ditch to considerable depth. We had a dam in the ditch below to hold the water in order to float us while at work. Two miles away a man was running a steam hay press, and he had a barrel sunk in the ground to serve him for a well. One night our dam broke away and let our water all out. On going to work the next morning the man with the hay press found his well dry.

Mr. Braucher.—What was the depth of the soil?

Mr. McGillis.—The soil was about ten feet.

Mr. Foster.—What time was that?

Mr. McGillis.—About two years ago.

Mr. Foster.—I think that was about the time my cellar went dry. (*Laughter*) Laying jokes aside, however, you cannot tell to what extent drains will draw water. I live in Englewood. My cellar had water in it to within two feet of the surface a good portion of the time. A sewer was constructed 285 feet from my house, eleven feet deep. Now my cellar is dry, and you can dig to a depth of eight feet below the surface and find it dry.

Mr. Mead.—Will a sewer with joints filled with cement drain much?

Mr. Foster.—A sewer as water tight as cement will make it will constantly take in water, as can be noticed by going through one. The pressure probably helps the admission of the water.

Mr. Clark.—A St. Louis engineer noticed that there was a waste of water from a large conduit of the water works. He built a cement cylinder to test its porosity and found there was very much waste of water on account of the porosity, until the sediment from the water formed a coat and then it seemed to be almost impervious.

A Voice.—That result would never have occurred, perhaps, with other than St. Louis water. (*Laughter*).

JUST APPORTIONMENT OF THE COST OF DRAINAGE IMPROVEMENTS.

By D. J. STANFORD, of Chatsworth.

In considering the subject, the just apportionment of the cost of drainage, it is safe to assume that the principle laid down by the drainage law of Illinois, that the cost should be apportioned according to the benefits, is in the main the correct one This assumption is no help toward the solution of the real question which then becomes: How shall we classify justly the benefits accruing from the proposed system of drainage. However carefully this classification may be made the result will only approximate exact justice.

While we may profitably discuss the principles involved, each separate case must be decided on its own merits, and will be modified more or less by many considerations, among which we may mention, first, the lay of the land, whether very level, full of pond holes, or rolling; second, whether the tract lies along the ditch or remote from it; third, the nature of the soil, whether porous or heavy; fourth. the nature of the subsoil, whether gravelly or hard pan; fifth, whether the district contains ponds of stagnant water. rendering the country unhealthful, which will be removed by the proposed system; sixth, the changing of the location of the ditch from the old channel or the cut-off; seventh, the benefit to highways, railroads and villages. All these questions arise. and in some cases they are so closely connected with each other that it is difficult to discuss each independently of the others.

1. In a district where the land is comparatively level, the quality of the soil is uniform and where the system contemplates constructing an outlet from every tract of land in the district, the labor of classifying is comparatively easy. In one such district with which the writer is acquainted. all the land in the district is classified at 100, and no appeals were taken, though the district was obliged to pay $2,400 to a lower district for an outlet. If a portion of a tract is rolling and the remainder low and wet, the area of the wet land should be carefully estimated; also the area partially benefited, with the percentage of benefits the higher land will receive. This only can be known by a knowledge of the nature of the soil and subsoil and the elevation. Those lands should not be taxed which lie high enough not to need the proposed ditch for an outlet for their drains; unless they are themselves wet and swampy, or are in the vicinity of

ponds of stagnant water which the proposed drainage scheme will remove and thereby render the vicinity more healthful.

2. When the system contemplates only a main ditch, leaving the branches to be constructed at a future time, and some of the tracts are quite remote from the ditch, I know of no better way than to classify as though each tract was to have an outlet. Estimate the cost of building outlets to each tract, add this cost to the engineer's estimate, then give those tracts lying away from the ditch credit for the amount necessary to construct an outlet for them.

When these branch ditches cross two or more tracts of land, the credits allowed to each should be in proportion to the benefits received by each from the proposed branch. The benefit, other things being equal, would be in direct proportion to the use made of the ditch by the several tracts. Many of these branch ditches will be of large tile and frequently would not be used by the tract nearest the main ditch, except to drain the narrow portion of the tract through which the tile passes.

3 and 4. The nature of the soil and subsoil should have its influence in the classification; for a tract of land having a gravelly or sandy subsoil and a porous surface soil will be much more benefited than a stiff clay with a hard pan subsoil, as in the former case an entire tract may sometimes be thoroughly drained by the one ditch, while in the latter thorough drainage will only be accomplished by a large outlay for tile drains. Again, a tract of land not entirely reclaimed may receive as great a percentage of benefits as another tract for which the proposed ditch will give an ample outlet for the complete tile drainage, the percentage of benefits being measured by the enhanced value of the land.

5. While there may be a question in the minds of some, the writer has no hesitation in saying that improved sanitary conditions are proper subjects to be considered in apportioning the cost of drainage improvement, for there is nothing that will enhance the value of our wet and swampy lands more quickly and surely than a knowledge that the cause of malarial diseases has been removed. But while I think that the greater healthfulness of a country should be classed as a benefit, there is probably no one thing that is more variable, for it is well known that while there is some land almost uninhabitable on account of the presence of malarious and kindred diseases, other tracts equally as flat are almost entirely exempt from them. At any rate, the percentage of benefits must depend entirely upon the judgment of the commissioners, aided, as they should be, by a full knowledge of all the facts in the case.

6. In laying out a system of drains the engineer will frequently find that the system can be made more efficient by straightening the old channel, or perhaps by changing the outlet, or by shortening the course to the outlet by a cut through a bank. These cut-offs usually add very much to the value of a ditch by leaving the farm land in better shape, by giving a more rapid fall to the ditch, and by short-

ening very much the distance. They sometimes add somewhat to the cost by requiring a greater depth of excavation in places, though this latter is usually over-balanced by the decreased distance and the diminished size of the ditch owing to the greater velocity of the flow. These cut-offs usually modify the benefits to a certain extent, but the same principles will control as in other cases, except where the water is taken entirely out of the old channel and carried to a new outlet in another stream. In that case lands lying along the old channel and below the outlet of the proposed ditch should be taxed for benefits from protection from overflow, but the per cent. of benefits can only be determined by a thorough knowledge of the facts in each particular case. This knowledge should include the extent of the overflow as nearly as may be by a careful examination of the lay of the land and a knowledge of the soil, for we find some lands that are badly overflowed at times have natural drainage, so that the lands will be good if the overflow can be turned away, while others are springy so that they must be drained to be of much value.

7. How highly lands should be taxed for prevention from overflow and how far down the old channel such tax would be allowable can only be determined by special knowledge in each particular case.

The rule laid down in the drainage law that highways and railroad companies shall pay toward the construction of a ditch the same proportion that its benefits bear to the total benefits in the district, though leaving a wide margin for a difference of opinion as to values, is without doubt correct in theory and will be as correct in practice as the judgment of the commissioners. Where a drainage district includes a town or city the rule for taxing the corporation for benefits to streets or as an outlet for sewers would be the same as for highways or railways, while the property owners would be subject to taxation for benefits to their property the same as farm lands, though the measure of value would be different.

In discussing this question I have not treated it as an engineering problem. I do not consider it to be one. There are certain principles involved, some of which I have endeavored to discuss. A knowledge of these together with a knowledge of the law; a thorough knowledge of the proposed system and a careful study of the topography and soil of each particular tract in the district; and a sound unbiased judgment form the qualifications necessary to a just apportionment of the cost of drainage; and I would adhere as closely as possible to the theory of the law that the cost of drainage should be in direct proportion to the benefits to be given, and endeavor to find out as accurately as possible the actual benefits that will accrue to each tract from the proposed improvement.

While going over the lands of the district for the purpose of classifying it I would want a map of the district on a large scale with all the proposed ditches and the wet lands, ponds, etc., located on it; also profiles of the ditches and also a book properly ruled in which the owners' names, a description of land, number of acres wet, number of

acres pond, and other data that would change in any way the classification. Then after making out these notes very fully I would make out the classification in the office with the map before me, where all the facts could be easily grouped together.

A few cases will occur wherein it is so clear that the benefits are not in proportion to the cost that I should hesitate to follow the law in this respect. I will mention one: We may find that lands near the outlet of a ditch, while flat and wet do not need as deep a ditch for their drainage as the lands above. Thus A owning wet lands near the outlet of a ditch would have those lands well drained by a ditch six feet deep, while the proper drainage of the lands above requires a ditch nine feet deep. Though A's benefits may be as great as B's whose lands lie above, A should be taxed for only his proportion of a ditch six feet deep; and his tax compared to B's would be in the proportion that the cost of constructing a six foot ditch bears to the cost of constructing anine foot ditch.

In conclusion I will only say that the problem, if it can be reduced to a problem, of "the just apportionment of the cost of drainage," though at first thought seemingly easy, is one that is modified by very many contingencies. and that after the engineer or board of commissioners may have established a system of rules that they think apply fairly to one district they will find that in another district they do not apply, and that another and entirely different set of rules must be adopted.

DISCUSSION.

Mr. Baker.—Mr. Gifford I think has had experience on both sides of this question. Would like to hear from him.

Mr. Gifford.—I do not stand as Professor Baker intimates. A piece of land near the mouth of the ditch may be subject to overflow in consequence of the construction of the ditch and I think the owner should certainly have damages accordingly. A neighbor is obliged to take water coming to him from above, but is not, I understand, required to keep a deep open ditch. All land within the watershed should be taxed for the drain, for the upper lands in my experience are the most difficult to drain. Would it not be well to have a drainage commissioner to act much in the same capacity as the school superintendent to the schools. The central part of Illinois depends largely on drainage for its development of wealth. I would rather have a 4 inch tile six feet deep than a 6 inch tile four feet deep.

Mr. Greeley.—Let me ask a single question. I own a half-section of land which needs no drainage. The other lands about me do need drainage. Is my land taxable for the drainage of the land about mine? I say, yes. The value of my property is affected by the condition of the lands about it, and the land will increase in value

accordingly as that about it is improved. A drain $5\frac{1}{2}$ miles long was built in the town of Cicero. The drain increased in size each half mile, beginning at the upper end until the outlet was reached. The property along the road was taxed alike. Was that just? I think not. The lands should have been taxed proportionately. The property along the half mile nearest the outlet should be taxed for a drain sufficient to drain that alone. The property next should be taxed for a drain sufficient to drain itself and for the additional cost of the enlarged capacity required in the drain below and so on through the entire distance.

Mr. Stanford.—My conclusions are different from Mr. Greeley's. An equal assessment was probably a just one. The land below must provide for the common surface drainage of that above and in this case probably as in others the land below was benefited in having the land above well underdrained, and hence should assist in performing that drainage.

Mr. Burt.—By Mr. Stanford's paper the man who requires the deepest cut to drain his property will pay the most expense.

Mr. Stanford.—That should be borne proportionately. If A and B have to drain through the same ditch, the ditch running through A's property, they should pay for it accordingly as each is benefited thereby.

Mr. Dunn.—Taking the lay of land into consideration, each piece of land should pay for its own drain and its proportion of the cost of the outlet. We meet this in large work composed of open ditches where the ditches run through only a small part of the entire land drained yet the ditch has to be large enough to drain all the land in the water-shed. I think all the land in the boundary of the water-shed should be included in the district and be assessed proportionately.

Mr. Stanford.—If the gentleman had bought his farm four or five miles from the outlet would he like to be assessed for the drainage of the land below?

Mr. Dunn.—When I drain my land artificially I ought to be willing to provide for the extra amount of water thrown in the outlet.

Mr. Stanford.—Does more water flow on account of artificial drainage?

Mr. Dunn.—I believe so. I have in mind several instances of ponds or basins near the top of a hill which before stood full of

water till it evaporated, but now the water runs off. I believe in deep tiling and ditching except in hard pan. Do not tile below the hard pan.

Mr. Bullard.—The question as viewed by cities is not without some value. The city of Chicago I understand pays by general tax for all the sewers. The business property in the heart of the city pays an equal proportion for building the sewers in the residence streets with the property directly benefited and *vice versa.* In Springfield the city by general tax pays for all trunk sewers while the laterals are built 80 per cent. by the property specially benefited and 20 per cent. by general taxation.

Mr. Foster.—In the Town of Lake the method is to build the main sewer by general taxation and construct the laterals from special taxation.

Mr. Gifford.—Drainage districts are organized and a man is required to pay for draining his land whether he wants to do so or not. It should be a question of right and equity.

EXTERIOR BOUNDARY OF TOWNSHIPS.

By F. HODGMAN, of Climax, Mich.

In all cases of double corners on township boundaries the instructions to the deputy surveyor required him to run his closing lines to their intersection with the township boundary, which boundary had been previously run and marked, and to place his closing corners at the points of intersection. In general it will be presumed that he did so, and the closing corners will be accepted as determining the location of the township boundary. But in many cases we have the most positive and conclusive evidence that the deputy surveyor did not locate the closing corner in the line previously run and marked for the township boundary as he was required to do, but placed it in some other position. Shall the township boundary be deflected in such cases to pass through these erroneous corners?

In accordance with the request of the Executive Board of the Illinois Society of Engineers and Surveyors I take pleasure in briefly presenting my reasons for holding to the belief that township and

range lines of the United States survey should not be deflected to pass through closing corners which were erroneously placed out of line by the original survey.

My first reason is that I think it contrary to the United States law to do so. Section 2, Paragraph 2d of the Act of February 11, 1805, says: "The boundary lines *actually run and marked* in the surveys returned by the Surveyor General or by the Surveyor of the lands south of the Tennessee, respectively, *shall be established as the proper boundary lines* of the sections or subdivisions *for which they were intended*, etc." Now the only lines which were actually run and marked along the township and range lines intended to be the boundary lines of the townships and sections adjacent thereto were the township and range lines themselves, which were run and marked previous to the subdivisions of the township. No such lines were run from the closing corners for that purpose.

For the purpose of illustration I will refer to an actual case to be found within a half mile of my residence. The north line of Township 3 South, Range 9 West, Meridian of Michigan, was run and marked in 1825. The township was subdivided in the spring of 1826. The notes of one of the subdivision lines, omitting immaterial portions, read as follows: "North between Sections 2 and 3, 82.02, Intersected N. boundary (post removed), set post at intersection corner to Sections 2 and 3." The adjoining township on the north was subdivided a little later in the same year. The marked trees along the township line and the bearing trees to the corners were still standing, and stood for many years afterward. In starting his line the surveyor found the corner of sections 34 and 35 and ran from it, making the following entry in his field notes: "Note.—Post, corner to sections 2 and 3, T. 3 S., R. 9 W., is 19 links too far north." It was evident that the surveyor who set the closing corner never tried to find the standard corner on the township line, as everything was plain except the post itself, and he could not have missed it. Here was a line actually run and marked for the north line of sections 2 and 3 and for the south line of sections 34 and 35. The surveyor who ran the closing line and set the closing corner ran a line which he intended for the west line of section 2 and for the east line of section 3. He set his corner post to define that line; but he did not run and mark lines east and west from that corner intended to be the north boundary of these sections. His instructions did not call for it. It was not in his contract to do it, and he would not have been paid for it if he had done it. And all for the good and sufficient reason that the township boundary was already established, and he had no power or authority from any source to change it. He might find and retrace the old line, but not make a new and different one without special instructions to that effect.

Now to deflect the township line away from the line which was actually run and marked for that purpose, to pass it through a corner which was 19 links too far north, where no line was ever run and

marked for the township line, seems to me to be contrary to law, to the instructions and to good common sense.

Second, I have read extensively the judicial decisions relating to boundary lines but have not yet met with one in which this point was at issue. Neither have I seen it passed upon in this form in any of the rulings of the General Land Office which I have read, but the following which I find in the Manual of Instructions to Surveyors General, of 1881, comes so near it that I present it as an additional reason for my belief. In giving directions how to proceed in retracing township lines when the original corners have been obliterated—just such a case as the last surveyor referred to in the foregoing illustration would have had if the corner on the township line had been actually obliterated—the instructions say: "New corners on township boundaries must be established by a survey of such lines, and *in no case* will such corners be established from data acquired in running lines closing on such boundaries." The italics are those of the Manual. This shows that the department considers these closing lines to be of *no value whatever* for the purpose of determining the township boundaries.

Lastly, I would not deflect these township boundaries away from their original location, because of the absurdities and impossibilities to which it might lead. Some of the errors in alignment of these closing corners arose from one cause and some from another. Most of those with which I am personally acquainted occurred from pure neglect, no attempt having been made by the surveyor to locate it any nearer the township boundary than his rodman could guess. In a number of instances they report the post removed; in which cases it is evident that they guessed at the line and let it go at that. Now take the illustration referred to before. Suppose the surveyor had run his closing line directly over the "post removed" and had planted his closing corner exactly in the section line 19 links too far north, which in fact was almost what he did; or, on the other hand, suppose he had fallen short of reaching the township boundary, when his line if continued far enough would have closed on the post. In either case it is absurd and impossible to deflect the township boundary so as to pass through both corners. With the closing corner in any other position than the two indicated, it becomes possible to so deflect the boundary; but to my mind the absurdity remains, the degree of absurdity varying with the position of the closing corner.

Since the above was written, I have met with a direct ruling from the General Land Office on the point in question. The point was brought up by Mr. Alter, of Indiana, and the Commissioner in reply says: "The township line is also the boundary line for the sections just south of that line, and the fact that certain closing corners were established somewhat beyond that line does not change that line, which must be the true line between the sections north and south of it."

PERPETUATION OF CORNERS.

By J. S. BURT, of Henry.

When requested by your Executive Committee to prepare a paper to be read before the society I felt that, so far as surveying is concerned, I belonged to the class "that should be seen and not heard;" that I should sit at the feet of the wise and drink from the fountain of their experience. While I cannot hope to say much that will be of benefit to the association, it may be that my blunders will provoke a discussion, from which much information may be evolved.

I am asked to prepare a paper upon the "Perpetuation of Corners," a work which I consider the most important of the land surveyor's duties; for no matter how careful and painstaking his preliminary researches into musty old deeds and the still mustier and more uncertain memory of the oldest inhabitant, no matter how careful the adjustment of compass, the projection of lines and accuracy of measurements, no matter how certain he may feel that the work is perfect and the result absolutely correct, yet, if he fails to mark his corners, he has come short of his duty, he has made a miserable failure.

The corner should be so marked that there will be no hesitation upon the part of any succeeding surveyor in regard to its being a corner, nor for that matter should there be anything about it that should raise a doubt in anybody's mind in regard to it.

The mark of a corner is a monument, and it should be known and recognized as such as soon as seen; for it is better to be able to find the corner by the monument than, as is too often the case, to be obliged to find the corner to prove that it is the monument. And I say, as I said before, that a survey that does not establish and define the corners by permanent and easily recognized monuments, is a miserable failure.

Having admitted that the most important part of the work of the land surveyor is to establish permanent monuments at the corners of the tract of land surveyed, the question that most naturally arises will be: "What shall such monuments consist of? what material shall we use?" In answering this question, the overwhelming majority of the answers would be stone. Its known durability; being almost unaffected by the ravages of time, its universal distribution and consequently its small cost, and the ease with which it is

worked into requisite shapes, place it at the head of all materials for monuments.

We have already said that we think monuments marking corners should be readily recognized, and we think this almost as essential as the durability of the monument. The practice has been with most surveyors to find a stone large enough, measure its dimensions, make a memorandum of measurements in the field-book, and bury the stone, although there may be a dozen nearly like it within a radius of a few feet and although if a question should arise several would have to be dug up, dimensions measured and compared with the note book, before the right one could be found, or some evil-minded person might remove the stone, fill up the hole and it would be impossible without a new survey to tell whether the corner were lost.

We think that practice bad that leaves the corner without some distinguishing marks, so there will be no hesitation in pronouncing a monument placed at a corner a corner stone, or, so that if gone, it will be missed immediately from its place, but may still be known as a corner stone wherever it is seen. Having condemned the practice of picking up anywhere a stone like hundreds of its fellows and using it as a monument, and wishing to get not only a uniformity but an individuality for our corner stones, it follows that we must lay out some work upon the stone before we use it; that is, the stones before being placed should all be partially cut so that the part exposed should be as nearly uniform as possible. And here we would suggest a stone from 14 to 16 inches long, 4 inches square for a distance of 6 inches from its upper end, and having a pyramidal top. It should when practicable extend above the ground 3 or 4 inches. Such a monument would fill all the conditions I have mentioned; it would be a distinguishing mark as well as a permanent one. Of course, to place a monument of this description in every corner would require a large number of them, and might be considered impracticable on account of the expense. While it is true that they would cost a large sum in the aggregate, yet to each individual the cost could be made trifling, and we think it would be cheerfully paid in almost all instances if the result is such as I claim for it, viz: a permanent and self-evident corner stone.

At the election last fall an amendment to the constitution of the state was adopted by the popular vote forbidding the letting of convict labor by contract, and much concern has been expressed lest the state should be obliged to keep convicts in idleness. Allow me to suggest a new industry, one that will conflict with no one, and will require no factories or expensive machinery, and but little skill in the laborer. It would seem to be the province of the state to make and supply these monuments. Let a form be established by law and the manufacture undertaken by the state, thus insuring a uniformity that could not be otherwise attained. If surveyors were compelled by law to see that such monuments were placed at each

principal corner of the lands they were called upon to survey, the demand for them would be very large, and would increase as their efficiency became known. To keep up the supply would furnish employment for a large number of men for a long time to come; and it may be that this will furnish a solution to the problem of convict labor.

In conclusion we would say that all section and quarter-section corners should be marked by a substantial stone cut in a distinctive form; that all corner stones should show above the ground in a uniform and unmistakable manner.

Right here I wish to say a few words in regard to displacing and removing corner stones. It should be made felony to remove a corner stone, no matter what the intention may be. The pernicious habit of removing monuments from corners whenever they interfere with a plough or are in the way while working the roads should be broken up. The monument that marks the boundary of our neighbor's land should be sacred. The old law was "Cursed be he that removeth his neighbor's landmark," and under the new law the severest punishment should be visited upon the man that removes the ancient landmarks, whether done with malicious intent or not; for no matter what care may be used in placing the monument, or how durable the material, it must be left to stand undistured or it ceases to be of any value.

DISCUSSION.

Mr. Greeley.—If these stones could be furnished by convict labor, how far could they be carried in the state?

Mr. Burt.—All over the state; the parties using them paying the freight.

Mr. Enos.—I generally fix government corners by taking four bricks and setting the corners together at the point to be fixed, setting them three or four feet below the ground, and then putting the stone above them. I sometimes place an iron pin below the bricks, so there is no possibility of losing the corner if the stone is removed. I would not set a stone extending above ground in a road.

Mr. Burt.—I say do that where practicable. I hardly think it would do to have the stone show above the ground in a road.

Mr. Hill.—Where vitrified sewer pipe may be had, a joint of pipe may be set in the ground and the hole filled with cinders or other materials.

Mr. Gordon.—I sometimes use boulders and with a cold chisel which I carry cut or mark a hole or cross. The laws of the state leave the furnishing of stones with the proprietors. In my county the proprietors hardly take the trouble to provide them.

Mr. McClanahan.—Stone monuments are not the best in Monmouth. My predecessor in office a good many years ago punched holes in the ground four or five feet deep in places where corners came in the streets, the holes being about half an inch in diameter, and filled the same with lime of the consistency of cream. They are the best monuments we have in Monmouth today and are almost indestructible. When not in streets or highways, cut stone is preferable.

Mr. Foster.—In the Town of Lake ten or more years ago, the board passed a resolution ordering the Engineer to put stones at street intersections 6x6 inches with cross on top. I suggested they be set 12 feet west and 12 feet south of the corner. They are yet in good condition. There is an an objection: the difficulty of fixing the corner; but that is more than counterbalanced by the safety of the monuments.

Mr. Mead.—In Rockford, to some extent, an iron tube about half an inch thick and ten inches long is used with success. An iron rod three-fourths of an inch in diameter and two and a half to four feet long is good. Boulders cut and marked are also used. I want to know a method of marking intersections of streets, whether in centers or on curbs or near street lines?

Mr. Greeley.—Chicago has done nothing municipally. Most surveyors use the curbstones, making eight marks at street intersections. In my practice I take everything at hand, buildings, posts, etc.

IMPORTANCE OF ACCURATE MEASUREMENT IN SURVEYING.

By D. L. BRAUCHER, of Lincoln.

The statement in the heading of my subject is somewhat axiomatic in its nature. I do not propose, therefore, to enter into any discussion of it to prove its truth to the members of this society. But my object will be to give some of my own experience in knotty problems met in the field from this cause and to elicit an expression of other's experience. I have set it down in my memoranda *in ink*, that exact measurement is a myth; yet it is a very desirable goal to reach, and the object in all our measurements is to make the nearest possible approximation to it. There is a great reproach to surveyors in the common saying that "no two surveyors will make it the same;" and to make it still more exasperating we must admit some truth in the saying.

If two good chainmen, at least one of them an expert, will take a good chain or tape, they may with great pains measure a distance of "one mile and repeat" with a difference falling inside of a half inch, the temperature being constant. One common source of error is in the changes of temperature; another common source of error is in the use of open-linked chains; but the greatest difference is caused by the change of chainmen; and when it is remembered that in our ordinary practice we seldom have the same chainmen in any two surveys, and are often compelled, under protest, of course, to use several different chainmen in one survey, it is not a wonder that "no two surveyors can make it the same." Indeed I find that one surveyor cannot make it twice alike, unless he be more expert than the writer.

I should long since have given up in despair but for the partial remedy we find in proportionate measurement. More than twenty years ago I had occasion to run a section line in Logan county twice inside of twenty-four hours, and had it measured both times with the same chain (Gurley's best steel open-linked) with the same average temperature, but with different chainmen, and the difference made was eighteen links; yet when I divided the line by each set of chainmen the points of division were not more than three inches apart. That was early in my experience as a surveyor, and it thoroughly converted me to the theory and importance of careful proportionate measurement in all re-surveys where accuracy is a desirable consideration.

To illustrate: I measure the west line of section 30, T. 21 N., R. 2 W. of the 3d P. M., and find it exceeds the call of the notes by 136 links. The line running east and west through the same section exceeds the call of the notes by 88 links; or a difference of 48 links, proportionate measurement, in the same section from the call of the original field notes. But I find a still more glaring difference in section 30, T. 20 N. and R. 1 W. of the 3d P. M. I measure the west line and find an excess of 24 links, and in the east line I find a deficit of 84 links, being a difference of 108 links in the length of lines on opposite sides of the same section. It thus appears that there is a difference of 220 links in the length of lines which are represented by the field-notes to be the same. I also find there is a difference of more than one and a half degrees in the course of lines which are represented to run on a true meridian, and which cannot be accounted for by reason of difference of longitude, being in the same or in adjoining townships.

The greatest obstacle to a uniform result in my opinion is the want of permanent and well-defined land marks. If our land and even our town sites and cities were carefully surveyed, making note of all measurements differing from the field notes or recorded plats, and also all angles carefully measured and noted, and then a record made of such survey to accord with the facts, surveying would then be in fact, as it is now in theory, one of the exact sciences—saving, of course, a mental reservation as to the meaning of *exact* in that connection. One of the demands of the present day is that some provision of law should establish permanently all of the original corners of our land as well as our city surveys, so that it would not be necessary for any surveyor to go outside of a section for landmarks to work from, nor outside of a block to get points for city surveying. This is alike important to owners of property and the reputation of surveyors and engineers.

In my experience I have made a few test measurements to ascertain the probable minimum limit of difference in measurement in running a distance of one mile. In such experiment I find it requires more care and more precision than I have ever been able to give it to reduce the difference so that it may fall between $\frac{1}{8}$ and $\frac{1}{4}$ inch per quarter of a mile or $\frac{1}{2}$ to 1 inch per mile. I do not know whether that will be regarded by those present as a minimum or not. If any have tried the experiment, I should be glad to hear a report of the result. In view of all the various sources of error, we are admonished that when we start from an original corner fully identified by well preserved witness trees, and run one mile either north or south with our compass and chain or transit and tape, we cannot take it for granted that the last pin at the end of eighty chains is necessarily on a section corner, but must remember that a correction, more or less, is likely to be needed in both measurement and course to locate the corner at its proper place. I will say in conclusion that the differences I have here cited are not the result of error in count,

but are wholly errors of measurement, resulting from the cause or the combined causes of error which I have cited above.

DISCUSSION.

Mr. Burt.—When the difference of measurements was only one or two inches what was your method?

Mr. Braucher.—I acted as one of the chainmen myself, in those cases.

Mr. Greeley.—What measuring instrument do you use ?

Mr. Braucher.—The chain.

Mr. Kyle.—We should have professional chainmen. The number of inaccurate measurements would be very much reduced.

Mr. Foster.—What variations in measurements are usually experienced in general work?

Mr. Ela.—Two to two and a half feet to the mile with a chain.

Mr. Braucher.—I have never with exactly the same conditions chained over the same line. Within a link to the half mile is good.

Mr. Kyle.—Some men are accurate to within one or one-half link and others vary ten or twelve links. I am much annoyed with poor chainmen.

Mr. Greeley.—We employ chainmen by the year. I used to chain myself till some time ago. Have found a difference of from three to five feet in former surveys. Possibly part was due to having a different starting point.

Mr. Braucher.—In Sangamon county last year in going over some work done by Mr. Enos, our proportional differences varied from one-half to one link per half mile.

Mr. Foster.—In 1870 I was called on to take the exterior lines of a town. The same lines were required to be measured three times. I found that the average difference in one mile was forty-five hundredths of a foot.

PAVEMENTS FOR SMALL CITIES.

By GEO. F. WIGHTMAN, of Peoria.

Assume that we are in a city of fifteen thousand inhabitants, located in one of the prairie states, and that the question arises:

How, and with what material shall our streets be paved?

In the solution of this question, economy and durability must be taken into consideration.

After many years of practical experience, I am confident that the pavements best adapted to cities of the size and in the localities aforesaid are first, gravel; second, Macadam; and third, brick. These are the most economical pavements. The most durable and most desirable pavement is granite. The smoothest, and from a strictly sanitary standpoint, the best pavement is asphalt. The cost of the two pavements last named, however, is so great that they can only be economically laid in the larger and wealthier cities, where the abutting property is worth from five hundred to a thousand dollars per foot front. Deeming this conclusive, let us proceed to the consideration of the first three pavements named, and in the order mentioned.

The following are the specifications prepared by myself for the guidance to contractors in the city of Peoria in the construction of gravel streets:

"*The Finished Pavement.*—In its cross section, it shall be an arc of a circle, with a rise of........inches in ....feet from the gutter of the center of the road each way. The roadway, when consolidated and finished, will be ten inches in depth at the center, diminishing gradually from this point, right and left, to the depth of eight inches at the curb stone.

"*The gutters* shall be three feet in width, and shall be made of cobble-stone, carefully laid and thoroughly rammed on a firmly consolidated foundation.

"*Preparation of the Roadway.*—The earth roadbed, on which the pavement is to rest, shall be excavated to the required depth, and when graded and shaped to its proper form it shall be repeatedly and thoroughly rolled with a road roller; and all depressions which shall then appear must be filled with the same material as the roadbed, and rolled until the whole shall be uniformly compact and firm.

"*Gravel Foundation.*--On the roadbed thus formed and compacted, a bottom layer of stone or coarse gravel is to be laid to a depth of six inches at the center of the road, gradually diminishing to four

inches at the gutter. The whole is then to be thoroughly rolled with a horse roller, and settled to place and compacted to the satisfaction of the City Engineer.

"*Surface Layer.*—On the foundation course will be spread a layer of clean gravel. The gravel must be uniform in quality, and must be raked into an even layer four inches in depth. The rolling shall then be resumed and continued with a constant light watering of the same until the *cross section* shall be exact, according to these specifications, and the roadway firmly compacted and made solid to the entire satisfaction of the City Engineer.

"*Pavement of Gutters.*—On the first course and after the same has been thoroughly compacted, the gutters will be paved, as provided for in the plans, with cobble-stone, the size and quality of which must first be approved by the City Engineer. The cobble-stone must be practically uniform in size, and must be set on end, vertically, and must be in close contact with each other at the base. The gutter thus laid shall have a thin layer of fine gravel spread over its entire surface and shall then be thoroughly rammed with a wooden rammer, weighing not less than sixty pounds."

Top Layer of Gravel Pavement.—The gravel for the top layer should be hard and tough, so as to withstand the heavy traffic to which it will be subjected. It should range in size from one-half inch to one and a half inches in its largest diameter, and should contain enough loam, clay or sand, or both, to bind it firmly together. A horse roller weighing, or loaded with stone until it would weigh, five or six tons would be sufficiently heavy for rolling the same.

Next in order is Macadam. The roadbed for this should be excavated and prepared in the same manner as for gravel pavement. After the necessary excavation the roadbed should be thoroughly rolled and if possible made as solid as a roadway itself. On this new surface thus formed and compacted a bottom layer of stone six inches in depth at the center of the street, and gradually diminishing to four inches in depth at a point four feet from the curb stone, should be laid by hand to form a close firm joint. All the interstices should be filled with stone chips, and all undue irregularities of the surface should be broken off. The whole should then be thoroughly rolled and settled to place. The gutters should now be paved with cobble-stone carefully laid in the manner provided for in the specifications for gravel streets. If, however, cobble-stone cannot be easily obtained at reasonable prices, a good quality of riprap stone should be substituted therefor and laid in the same manner as described in the gravel pavement specifications. After the gutters are paved, then on the foundation course of stone a layer of broken granite four inches in thickness should be placed. This course can be prepared from granite boulders if the vicinity in which the work is to be done abounds in them, but if not and the expense of procuring them should be found too great, they may be omitted altogether; and in such case the surface layer should be finished off with a coat of

the best quality of clean gravel four inches in thickness and in the same manner as described in the specifications for gravel streets.

An inferior quality of stone for the subpavement may be used, and such are often found in abundance in many localities, such as sandstone and the softer varieties of limestone. They are entirely suitable for the bottom course, but do not possess the requisite hardness for the top layer, and must not under any circumstances be used for top coating. If, however, this poorer quality of stone be used for the subpavement, then in such case the same should be laid one or two inches greater in thickness.

We now come to the consideration of brick pavement. This pavement is regarded by many engineers as entirely experimental, although in cities where it has been possible to secure suitable brick, as in Bloomington, Galesburg, Jacksonville, Chicago, and Peoria, brick pavements have been laid, which already show remarkable qualities of endurance; and those most interested claim that brick pavement has passed the experimental period. Where the laying of brick pavement is contemplated, the first and all-important question to decide is, "Can brick be obtained that possess the *requisite uniform* hardness?" My experience warrants me in the conclusion that there are but a few localities in which clay has been found that will stand, without fusing, the amount of fire necessary to make a brick hard enough for street pavement. This, however, is a matter for the brick manufacturers to regulate and settle, and upon their success depends the future of brick pavement for streets. It is a matter of history, that brick in every way suitable for street paving have been made in Bloomington and Ottawa, in this state, and in Haydenville, Ohio, and in other cities. Some of these pavements, although laid ten years ago, present at the present time not only a uniform but very smooth surface. This fact taken in connection with the additional one that no repairs worth mentioning have been made on these pavements during all these years speak volumes for the pavement under consideration.

The usual method of laying brick pavement is as follows: Excavate to the required depth, say ten inches below the grade line; roll and solidify the foundation as required in the specifications for Macadam; then cover with a four inch layer of sand. Lay the first course of brick flat upon this sand layer and lengthwise with the street, breaking joints the same as masons do in laying a wall. Tamp this layer of brick down solidly, and fill the interstices with dry sand, sweeping it in thoroughly. Spread on this layer of brick thus tamped and prepared another layer of sand one inch in thickness, carefully smoothed over the whole surface. On this layer of sand set a course of brick on edge, and crosswise of the street; sweep the interstices full of dry sand, cover the whole with a layer of sand an inch thick, and your street is ready for public use. I want to be understood to say that the brick used in this upper surface course must be burned to a flint hardness, and any want of uniformity in

this particular will result in an unequal wear and will in a short time give you a pavement with an irregular surface.

The cost of making these pavements depends largely upon the facilities for procuring the selected material, be it gravel, stone or brick, but it should not in any event exceed seventy-five cents per square yard for gravel, one dollar and fifteen cents for Macadam and one dollar and fifty cents for brick pavement. This includes the entire expense of the respective pavements treated of, from the survey to the completion of the street ready for use.

Streets once paved should be well taken care of, especially the gravel and Macadam paved streets, for when neglected they soon become dusty and muddy, a condition that readily excites abuse of any thoroughfare and calls slanders and curses upon the municipality that projected and maintains such a system of roadways. As soon as the surface has become hard and smooth, care should be taken that this condition be maintained, irrespective of the amount of travel. Every improved street should be kept clear of dust and consequently clear of mud. Surface repairs should be made often; and as soon as ruts or depressions become visible new material should replace such wear or displacement. In fact they should be carefully looked after every day in the year, cleaned as often as they become dirty, and repaired as frequently as necessity requires. By these means the surface exposed to the the traffic will be kept regular, smooth, clean and up to grade year after year with much less expense and much more satisfaction to all concerned, than under the system of annual or semi-annual repairs. Without continual care, a constantly good roadway is an impossibility.

Observe these two rules:—

First, sweep off the dust as fast as it appears.

Second, fill up the depressions and bad places, with new material, as soon as they are formed.

Follow these instructions and you will have at all times a smooth pavement and a clean street.

A very gratifying feature of this exhibit is found in the fact that should the municipal authorities tire or become dissatisfied with either or all of these pavements and desire to convert the same into one of the finest qualities of roadways known, it can quickly and very cheaply be done by putting on a three inch layer of asphalt, the cost of which would not exceed one dollar per square yard. Such a pavement would answer all sanitary requirements. It contains no material that is affected by acids or alkaline solvents of liquid filth. It is less noisy than even wooden block pavement. It costs less for repairs than any other except granite, and next to stone lasts the longest. The sheet asphalt can be adapted to any old pavement of brick, Macadam or gravel. I have named these foundations in the order of their respective merit.

In conclusion it may be said that brick pavements are being laid better every year. The inventive genius of the brick manufacturers

throughout the country has been greatly stimulated in this direction by the ready markets waiting their wares. New methods have been devised and new machinery has been invented, and the public mind is fast being educated to believe that if brick can be burned hard enough and in sufficient quantities it is the material above all others that should be used for economical street pavement in small cities. Therefore, let us hope that the brick manufacturers will continue their researches in the world of science, until their worthy efforts shall be crowned with success.

DISCUSSION.

Mr. Bell.—Samples are on the table there of brick which have been in service in pavements in Bloomington 14 years—some 9 years; and also a sample of brick we now use. The wear is immaterial, not over half an inch in ten to fourteen years.

Mr. Baker.—What does Mr. Bell think of laying a pavement without the usual sand or gravel foundation?

Mr. Bell.—The lower layer of brick acts as a bed or support. We have some pavement laid under a patent, the brick being covered with a sort of creosote or tar. The brick being soft to begin with did not give the best satisfaction. It is the first pavement to get dry after a rain. In Nashville, Tenn., they are using a creosoted brick. I have here the specifications under which it is done. In Wheeling, W. Va., they are laying brick pavement of only one thickness or layer.

Mr. Bullard.—What is the object sought in creosoting the brick? Is it to render the brick non-absorbent?

Mr. Bell.—Yes, sir.

Mr. Mead.—In Wheeling a peculiar form of brick made of clay and iron slag is used. In shape it is a truncated pyramid.

Mr. Bell.—The Philadelphia committee that examined the streets of Wheeling also report that in 1883 they saw some brick pavement in St. Louis that had been down two years on Pine street and subjected to the severest wear, and the wear does not exceed one-sixteenth inch per year.

Mr. Sizer.—What sort of brick is used, pressed or ordinary?

Mr. Bell.—The ordinary moulded brick, as the sample will show.

Mr. Greeley.—What is the shape of the cross section of the street as laid? I like that straight on the haunches and rounded in the center rather than a curve the entire width of the street. I noticed in 1880 while in London that the wood pavement was being

very much used. They lay it on a concrete foundation six inches in thickness.

Mr. Bell.—We usually lay pavement with about seven inches curvature in a width of 36 feet between curbstones.

Mr. Gordon.—I would make the rise more than that in Bloomington, and make straight line to the gutter.

Mr. Bullard.—We have experienced some difficulty in Springfield with the blocks of the wood pavement swelling after a rain and raising themselves near the center of the street several inches off the bed boards. The cross section of the street is a curve, and the arch is so strong that it will bear up light vehicles in passing over, even though the blocks have raised six inches off the beds.

Mr. Clark.—In St. Louis in the last two years a great deal of granite block pavement has been laid, partly on concrete foundation and partly on Macadam. Two or three residence streets are paved with asphaltum on concrete. Wood pavement has been laid mostly on concrete. After the blocks were laid, a thin coat of composition was laid over them. In cold weather wood pavements crack badly. The asphalt gives excellent satisfaction.

Mr. Mead.—The National Board of Public Health ordered the wood pavements of the city of Memphis entirely removed from the city, while examining into the cause of an epidemic there a few years ago.

BY WHAT MODE ARE THE UNESTABLISHED QUARTER SECTION CORNERS ON THE TOWNSHIP AND RANGE LINES TO BE MADE FOR THE FRACTIONAL SECTIONS ALONG THOSE LINES?

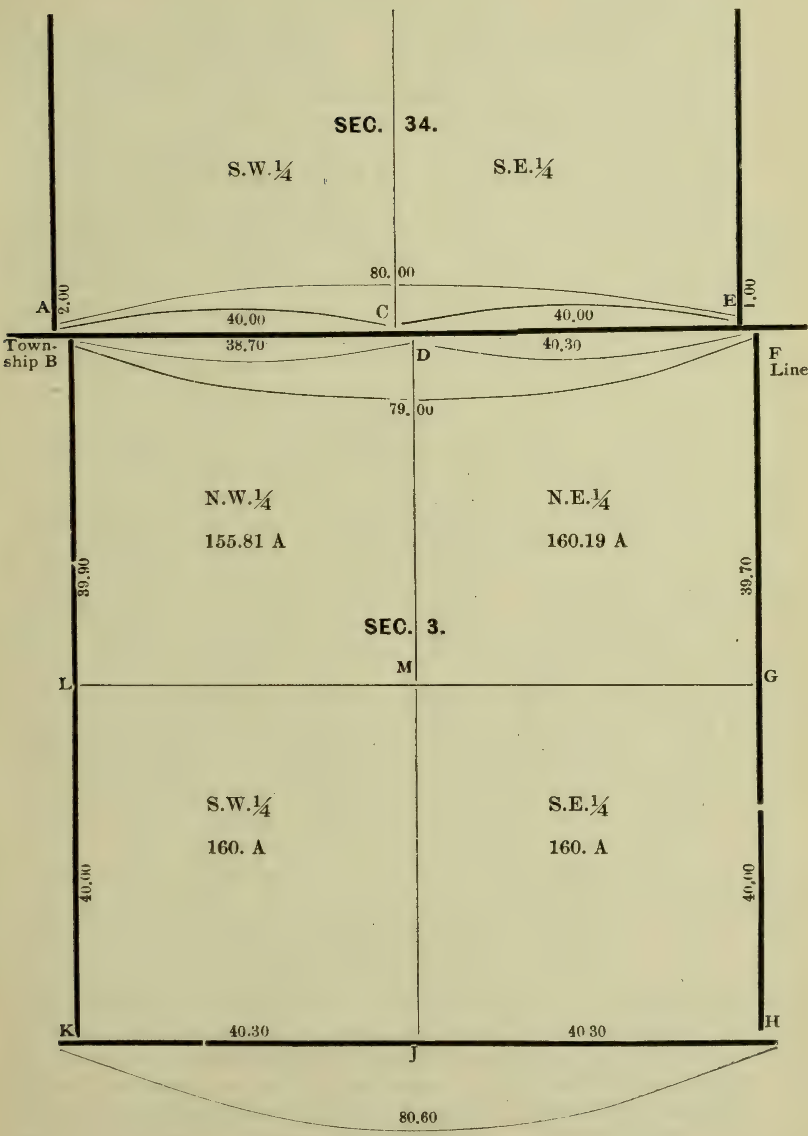
By Z. A. ENOS, of Springfield.

The plan as first adopted by the Land Department of the Government for subdividing the Townships, has undergone various and material changes from the date of its inauguration to the present time. But it is not a history of these changes that I propose to consider; it is only one of its different phases of which I shall treat. In this state, and I presume the same is true in other western states in which the U. S. Surveys were executed at the same date, nearly all the surveys were made upon what is known as the double corner system; that is, separate section corners on the township and range lines. Now it is the mode of subdividing these fractional sections into $\frac{1}{4}$ sections that I propose to discuss, or more especially the proper making of the unestablished $\frac{1}{4}$ section corners (for these fractional sections) on the township and range lines. In much of the southern part of the state the $\frac{1}{4}$ section corners established for the south and east sides of the township and range lines are assumed (in the calculations of the areas and plats returned by the Surveyor General) as the true $\frac{1}{4}$ corners for the fractional sections on the north and west sides of the Townships; and this also was the original plan (as shown by the plats) for a considerable portion of the military tract in this state, though the plats were subsequently changed to conform to the more modern method. But in the northern and central parts, and also a small portion of the S. E. part of the state, this is not the case, and the $\frac{1}{4}$ section corners have to be made by the county or private surveyor; and the making of these unestablished $\frac{1}{4}$ section corners, and thereby determining their connecting half section lines, has been a fruitful cause of contention among surveyors.

Before proceeding further with the consideration of the subject, it perhaps would be well to explain, for the information of non-professionals in surveying, that in the survey of the exterior boundary lines of a township, under the double corner system (while the section and $\frac{1}{4}$ section corners were established at every mile and half mile on those lines) it was only the corners that were made on the south and east boundary lines that belonged to the township, the

section and $\frac{1}{4}$ section corners made on the west and north boundary lines being made for and belonging to the townships west and north of those lines; and that in the subdivision of the township into sections the subdivision surveyor established the section corners on the north and west boundary lines for the north and west tiers of fractional sections adjoining these lines, thus making double section corners along each township line. And in making these corners, the subdivision surveyor did not remeasure the township lines, but at the points where in running north and west his subdivision section lines intersected the north and west boundaries of the township, he established his section corners, and merely measured the falling from or distances between each intersection and its nearest section corner of the township survey; and from these fallings and the measured lengths of the sections in the township survey, the lengths of the fractional section and $\frac{1}{4}$ section lines adjoining the north and west boundaries of the township were then computed, and these computed lengths of lines were used in the calculations of the areas of the abutting fractional $\frac{1}{4}$ sections. The lengths of lines thus found and the areas so calculated were marked upon all the plats of survey for central and northern Illinois, as returned by the Surveyor General. In most of the southern part of the state, where the $\frac{1}{4}$ section corner is assumed to be common to both sections, the returns do not show the lengths of these computed lines, but give the areas of the $\frac{1}{4}$ sections as calculated from the lines so computed.

The manner of computing the lengths of these section and $\frac{1}{4}$ section lines was, taking for illustration the returned length of any full section in the township survey, and the fallings or intersection distances from its corners of the corners of the adjoining fractional section in the subdivision survey; then, if both the fractional corners fell within (that is between the corners of) the full section, the sum of the fallings was subtracted from the length of the full section line, and the remainder was the computed length of the fractional section; if both fractional corners fell without the corners of the full section, the sum of the fallings was added to the length of the full section for the length of the fractional section, and if one falling was within and one without, the difference of the fallings was subtracted if the greater falling was within, and added if the greater falling was without. Thus, taking two contiguous sections on opposite sides of the township line, say sections 3 and 34 as shown by the accompanying plat, the return length of section 34 was 80 chains, and the fallings for corners of section 3 are represented as 1 and 2 chains east of the corners to section 34 (one within and one without the corners of the full section), the greater falling being within, consequently their difference of one chain was subtracted from 80 chains, leaving 79 chains as the length of the north boundary line of fractional section 3.


SEC. 34.
S.W.¼
S.E.¼
80.00
A
2.00
40.00
C
40.00
E
1.00
Township B
38.70
D
40.30
F
Line
79.00
N.W.¼
155.81 A
N.E.¼
160.19 A
39.90
39.70
SEC. 3.
M
L
G
S.W.¼
160. A
S.E.¼
160. A
40.00
40.00
K
40.30
40 30
H
J
80.60

The lengths of the north boundary lines of N. E. and N. W. fractional ¼ sections, were then obtained by three distinct and different modes, as follows: In a few instances of the first surveys in the state, apparently, the length of the north boundary line of section 3, found as above, was bisected for the lengths of the ¼ section lines, making each ¼ section line 39.50 chains long, and these lengths, when not shown, are to be inferred from the areas which are so marked on the plat returned; though in most all of the early surveys in the south part of the state, where as previously stated the ¼ section corners made for the full sections in the township survey were assumed as the ¼ section corners for the adjoining fractional ¼ sections, the lengths of these fractional ¼ sections were computed in the following manner, viz.: The south boundary lines of the S. E. and S. W. quarters of section 34 were returned as 40 chains each, and the N. E. corner of section 3 being without one chain east, consequently as the ¼ section corner for section 34 was common for both sections, the computed length of the north boundary line of the N. E. ¼ of section 3 was was 40 plus 1 chain, equal to 41 chains in length; and for similar reasons, the N. W. corner of section 3 falling within or east 2 chains from the S. W. corner of Section 34, the north boundary line of the N. W. ¼ of section 3 would be 40 minus 2, equal 38 chains long. These last computed distances are but in very few instances returned on the plats, but the contents of the fractional ¼ sections, calculated from the lengths of the lines so computed, are returned on all the plats. But in all the later surveys in Illinois. from 1817 until their completion, which cover the whole of the northern and central and a portion of the southeastern part of the state, the mode of ascertaining the lengths of the north boundary lines of the N. E. and N. W. quarters of section 3, was to take one-half of the returned length of the south boundary of section 3, (viz., 40.30 chains) and assume that number of chains as the length of the north boundary of the N. E. ½, and subtracting this distance from 79 chains, the ascertained length of the north boundary line of the section, left 38.70 chains as the length of the north boundary line of the N. W. ¼; and these lengths of line were not only used in the calculations of the contents of the ¼ sections, but with those contents were marked on the plats returned, by which the ¼ sections were sold. Now it is these computed lines so marked on the plats returned by the Surveyor General, or when not marked that are clearly understood and readily calculated from the lines actually run and the areas of the ¼ sections returned (by which the lands are sold), that constitute the governing principles or rules and regulations prescribed for the subdivision of fractional sections, that determine the manner of their division into ¼ sections and locates the unestablished or assumed ¼ section corners. But it is the consideration of this last mode of subdividing the fractional sections to which I shall call attention, and to which I propose to confine this article.

There are no less than four different modes made use of by sur-

veyors, each theoretically right, and producing the same result (provided always, that the government surveys are perfectly accurate) but practically differing widely in the placing of the quarter section corners and determining the half section lines, owing to the inaccuracies of the original surveys. These different modes of survey and the consequent difference in the results, will be best seen and understood by referring to the foregoing plat of fractional section 3. The lines upon the plat are shown to be straight and their lengths are the measured lengths returned, or such as were calculated in the Surveyor General's Office, and the corners were all made by the government surveyors except the quarter section corner D, which is to be made, and the line D J established. Now, by the first mode we run the east line of the section H G F and ascertain the bearing or variation of needle tracing its two halves, H G and G P. Then starting from J, the quarter section corner on the south boundary, run the line, J M D, north parallel with the east boundary, H G F, intersecting the north boundary line C E at D. The point of intersection D is the quarter section corner, and J M D is the half section line, according to this plan.

Plan No. 2 begins at H, the S. E. corner of the section, and carefully measures the distance H J; then from F, the N. E. corner, runs west along the north boundary line of the section, the distance F D, equal to H J, and establishes the quarter corner at the point D, connecting D and J by the straight line D J.

Plan No. 3 takes the distance C E, 40 chains in length as given in the government notes (being the south boundary line of the S. E. quarter of section 34) and adds to it the length of the falling or jog E F, 1 chain, making 41 chains, according to government measurement, and from this sum subtracts the distance 40.30 chains, the assumed length of the north boundary line of the N. E. quarter of section 3, as shown by the plats, leaving 70 links remainder; then from C, the quarter section corner for section 34, runs east on line C E, and 70 links distant from C makes the quarter corner for section 3, and connects D J.

Plan No. 4 commences at B or F, the N. E. and N. W. corners of section 3, and measures the whole length of the north boundary, B F, and places the quarter section corner D at the respective proportional distances of 40.30 and 38.70 chains from B and F, as shown on the plats, and connects D and J by a straight line.

Now if the work of the government surveyors was correct, the measurements and alignments accurate, and also the work of the private surveyor good work and true, then the quarter section corner D and the half section line D J will be the same by either of the four modes of survey. On the contrary, suppose the original surveys are inaccurate in alignments and distances, as they really are, then each mode will produce a different result. For example, let us assume that J is not equally distant from the section corners H and K, or C from the section corners A and E, and that the quarter section corner G is not in right line between the section corners H and F;

that upon a re-survey it is ascertained that H J is 40.15 chains and J K 40.35 chains long, A C 40.08 chains, and C E 40.22 chains long, and that G is 25 links east of a straight line from H to F. Now the 1st and 2d modes of survey would make the quarter section corner D the same; but the 1st would make D J a crooked half section line; the 2d, a straight half section line. The 3d mode of survey would place the quarter section corner D 37 links further west than the 1st or 2d mode, also make a different half section line; and the 4th mode would place the quarter section D 7 links east of the 3d mode, and consequently make a different half section line from either. Now, while it is the presumption of law that the government surveys are correct, accurate in line and measurement, and lines all bisected or divided as shown or indicated by the government notes and plats, the facts in the case are exactly the reverse. The line H J will rarely prove the half of H K, much less the 4030-7900 of B F, as was assumed in the government computation of the length of lines and areas, and these assumed correct lines, but really incorrect lines, are made the foundation or bases of the 1st and 2d modes for surveying and establishing the quarter section corner D. Nor is the line C E any more likely to prove the half of A E, and consequently D F be the 4030-7900 of B F, the fact or base assumed for the 3d mode of making the quarter section corner D. The first two modes of establishing the quarter section corner D carries to the north boundary line of the section whatever error there may be in the division of the south boundary line H K, arising from the placing of the quarter section corner J either too far east or west, and makes a corresponding error at the quarter section corner D in the north line B F.

The 3d mode takes the error, whatever it may be, in the division of the line A E in another section (section 34) and transfers it to the line B F in section 3.

Now, while the running of the half section line J D north or parallel with the section line H G F to the intersection of the township line C E, and there establishing the quarter section corner D, would in part be in analogy to the manner of establishing the section line H G F and the section corner F, yet the analogy would not be perfect, for the quarter corner M or center of section 3 is not like the quarter section corner G, placed by law at the even 40 chains measurement, but at the point where the line D J would intersect the half section line G L, be that distance more or less than 40 chains.

And further, the fact that the length of the line D F as returned on the plat, is one-half as much as the returned length of H K, does not establish a rule that the half section line J D is to be run exactly parallel with the section line H G F, for the length of the line B D is also returned, and the sum of the lengths B D and D F make the whole length B F, and there is nothing on the face of the plat, or in any way indicated by the returns, that would attach more weight or importance to one line than the other; and, therefore, nothing can

be inferred from the returned length of D F, other than that it is 4030-7900 of B F, or that B F is to be divided in the returned proportions of B D and D F. And although the areas of the N. E. and N. W. quarters of section 3 were calculated from the returned lengths B D and D F; and that D F was assumed in said calculations to be one-half of H K, it does not therefore follow that the length D F is to be changed and made the exact equal of H J, for the length D F is 40.30 chains of the township chaining, and the chainings of the township and subdivision surveys were not equal; that is, 40.30 chains of the township survey was not the equivalent of 40.30 chains of the subdivision survey. And this is manifest from there being a north tier of fractional sections; for had there been no inequality in these chainings there would have been no excess or deficiency of measurement to be added to or deducted from the north tier of sections, and consequently there would not have been any fractional sections on the north. And the act of May 10th, 1800, evidently contemplated such a difference in chaining and made provision for its disposal as above, by requiring that the excess or deficiency of measurement should be added to or deducted from the northern ranges of sections.

And moreover, the running of a line from J north actually parallel with H G F would conflict with and change two returned distances, B D and D F, and these two distances would have to giv way to one assumed course, which would be in violation of the well established rules of legal construction, that the majority in weight of evidence must control.

Nor does the method of running from the established quarter section corner J due north to the exterior boundary of the fractional section, in the manner as provided by the 2d section of the act of 1805, apply, for the reason that although there is no opposite corresponding quarter section corner fixed, yet there being no insuperable obstacle in the way, such a corner can be fixed, and a departure from the general rule of running a straight line from the established quarter section corner to its opposite corresponding corner, as required by said 2d clause, is only permitted in cases where no such opposite corresponding quarter section corner can be fixed, or where the division lines are made in pursuance of the rules and regulations of the Secretary of the Treasury, as provided in the acts of April 24th, 1820, and April 5th, 1832.

And then again, although it is claimed by the advocates of the 3d mode, or assumed falling C D, that as the quarter section corner at C is in law presumed to be exactly 40 chains distant from each of the corners A and E, then to the length C E, 40 chains, adding the falling E F 1 chain, making C F 41 chains, and subtracting from this sum D F 40.30 chains, leaving 70 links remainder as the assumed falling or distance between C and D, is a strict compliance with the presumptions and requirements of the law. But while admitting that the quarter section corner C is in law presumably correct in all

respects, so far as relates to the boundary and subdivision of section 34 in the north township, yet we deny that it is to control the subdivision of section 3 in the south township, or that it has anything to do with it, other than it is a point serving to define the line between the two townships; for nowhere in the returns of the subdivision, survey and plat is there any connection made with or reference to it, not even being as much as marked on the plat of township containing section 3, and for all that is shown on this township plat, having no existence. And the Manual of Instructions to Surveyors for Illinois and Missouri states that the quarter section corner at D for section 3 is to be made without any respect or any attention to the quarter section corner at C, the latter belonging to the section in the other township. Then with what justice can it be claimed that such a mode of making the quarter section corner D is in accordance with the plan for the subdivision of fractional sections which was adopted by Surveyor General Rector, and which the Secretary of the Treasury approved, and made the general rule and regulation in pursuance of the provisions of the act of April 24th, 1820, inasmuch as the Surveyor General's returns do not show any such plan or mode of subdivision, but on the contrary the returns show those facts which clearly indicate that the 4th mode of subdivision was the plan adopted by him.

Each of the first three modes of survey are subject to the serious, if not fatal objection, that they multiply and perpetuate the errors of the original surveys, instead of correcting or checking their further progress, and the 3d mode, while the shortest and easiest of execution, and therefore most used by surveyors, is on the score of error the most objectionable of all, inasmuch as it adds to the errors in the division of section 3 the additional errors that may be in the south line of section 34, all arising from its wrong bisecting or a wrong noting of the falling off from its corners. The 4th mode makes no assumption as to the accuracy of the bisections or lengths of the measured lines; takes nothing for granted, but carefully measures the whole length of the north line of section 3 (B F), and ascertains whatever excess or deficiency there is in its whole length as given by the government plat, and distributes that loss or gain between its parts, the quarter section lines B D and D F, according to their lengths as represented or indicated by said plat, and thus locates the unestablished quarter section corner D upon just and equitable principles. And it is these computed lengths of line, B D and D F, as shown on the plat by which the lands were sold, that was intended should govern the divisions. If not to govern the divisions why were they used to ascertain the contents, and why shown at all; or, if the quarter corner for 34 was to control the quarter corner for 3, why was not the assumed falling C D given; but the falling C D is not given, and the distances B D and D F are given, and the conclusion must be inevitable that the marked distances and not the unmarked falling is what the Surveyor General

intended should govern and control the quarter section corner D, under the rules and regulations of the Secretary of the Treasury, and these rules and regulations are only to be obtained from the returns of the Surveyor General as shown upon the face of the plats; for the Secretary of the Treasury did not issue any formal rules and regulations, but merely approved the plan for the subdivision of fractional sections as adopted by General Rector (Surveyor General for Illinois and Missouri), and directed that the plan should be generally adopted. And since that ruling the lengths of these fractional quarter section lines have been shown on all the plats of survey returned for the State of Illinois. And further, as previously stated, the courts hold that when lands are sold by plat on which the lengths of the lines are marked yet the corners not actually made, the corners must be established in conformity with the distances as shown by the plat.

After a careful consideration of the law and all the facts in relation to each of the four modes of making the unestablished fractional quarter section corner, and half section line as above stated, with the reasons for and against each mode, I have but little doubt in my own mind that the fourth or last named mode is the correct one; but from the full presentation made each reader will be enabled to determine for himself as to which is the proper mode.

RESERVOIRS FOR RAILROADS, MILLS, FARM USE, ETC.

By S. F. BALCOM, of Champaign.

The practice of storing water in large quantities for use in connection with mills, factories, etc., is an old one. Who can not remember some old mill with its picturesque mill-race and wheel? Perhaps the location was in the woods, at the side of some shady stream, and the mill-dam made of brush, with the water seething through; or, possibly, it was of earth and large stones—the latter covered with moss and made slippery by the stream, as it glided around or over them, forming a slippery path of stepping stones that venturesome youth was ever ready to test.

Water thus stored furnished motive power by means of a mill-race and water-wheel, and in these cases the hand of nature pointed out the location. The creek or large ravine, with a narrow channel at

some point, determined the mill site. The required dam was then built, the mill-race constructed and the first heavy rain completed the mill-pond ready for use. In many cases it was not only useful, but ornamental as well; for bushes and trees often fringed the banks, and fish found a home in the water. It had charms both in summer and winter, which for years linger pleasantly in the memory.

Reservoirs differ somewhat from mill-ponds. They require less from nature, can be located more nearly where wanted, and are almost entirely artificial. They have come into use not so much from choice, perhaps, as from necessity. In the case of railroads, where reservoirs are most in use, the wells which are usually the first source of water supply, soon become inadequate, and their use is a source of heavy expense. Well water is also objectionable on account of the lime it contains. The quality of the water has a great deal to do with the cost of maintenance of boilers; as will appear from the fact that the alkali in the water of some western states will render the flues unfit for use in the short space of six months; while on the other hand, sets of flues on the Southern Division of the Illinois Central Railroad, where surface water is used, have been known to last fifteen years without repairs. But the main cause of the introduction of reservoirs was the inability of wells to furnish the required amount of water at all times and seasons. The amount required has also steadily increased; for while a locomotive some years ago consumed from twelve to fifteen hundred gallons of water in running twenty-five miles, they now use from fifteen hundred to three thousand gallons in going the same distance. The extra amount is made necessary by the increased number of loads that are now hauled in a train, and the increased weight of the loads from ten tons to fifteen and twenty tons per car.

One of the first reservoirs built on the line of the Illinois Central Railroad was at South Neoga Tank. It had a capacity when built of about four million gallons. Reservoirs have also been excavated at Kinmundy, and at the first station north of Mattoon. These, with water from Crooked Creek and Little Wabash river, give surface water for passenger engines between Centralia and Champaign, except at Champaign, where only a partial supply of surface water is had.

Twenty years ago there were sixteen water stations between Champaign and Centralia, a tank for every eight miles. At nine points the water was pumped by windmills or by hand, at three places by horse-power, and at four stations by steam. These sixteen water stations have now been reduced to six, and the pumping is done by steam. They are now an average distance of twenty miles apart; instead of eight miles as formerly. The standard tender on the Illinois Central Railroad now has a capacity of 3,000 gallons, and as soon as all locomotives are supplied with tenders of this capacity the average distance can be made still greater; although the rate of consumption will probably continue to increase.

During the severe drouth of last season the reservoirs on the section of road just named partially failed; but by taking water at Mattoon, furnished by the City Water Company, and in some cases using double tenders, the road was able to handle its business.

In the construction of reservoirs the location desired is one that has a sufficient water-shed to furnish the required amount of water; also one that has a natural basin, in order that when the water is confined it shall not back up on or overflow adjoining land. It should, of course, be as near as practicable to the supply tank, so that the cost of pipes for conveying the water from the pump would not be too great. The Illinois Central Company, however, conveys water in this way at Little Wabash river nearly one and a half miles, and at Crooked Creek about two and a quarter miles; and at Anna, in Union county, the water is pumped from a spring and forced about one-half mile to a tank on the top of a hill, from whence it gravitates through pipes to the supply tank at Anna station, a distance of about one mile.

The cost of excavation will depend on the nature of the earth at the point where the reservoir is located. Examination should be made if stone or beds of gravel are liable to be encountered. The cost of excavation at South Neoga in 1869 was about 22c per cubic yard; and at Kinmundy in 1885 the cost was 19½c per cubic yard. The reservoir last mentioned was formerly a second or third class water station, the supply being furnished by a well and the pumping done by windmill and by hand. It has within the last two years been made a first-class water station, a reservoir of nearly two million gallons capacity having been excavated, a brick engine house built, and a new tank or tub erected. In constructing the latter, which is some 700 feet from the pump house, a new plan was adopted, that of setting the tank, which is placed on open framework, back some 50 feet from the track, and of supplying the locomotive tenders by means of pipes and a penstock. Taking the expense of constructing this water station as a basis, a fair cost of water supply can be arrived at. The cost of the reservoir at Kinmundy, however, was only one-half the following estimated amount, as it contains but two million gallons, while a standard reservoir should contain at least four million gallons.

COST OF A FIRST-CLASS WATER STATION.

Reservoir		$3,000 00
Plant:—		
Engine-house, tank and penstock	$1,950 00	
Machinery and pipes	750 00	2,700 00
Total amount invested		5,700 00
Interest on investment at 6 per cent	$ 342 00	
Depreciation and expense of plant at 5 per cent.	135 00	
Wages of pumper	420 00	897 00

ESTIMATED AMOUNT OF WATER USED.

3 passenger engines and 7 freight engines each way daily, equivalent to 20 tenders of 2,000 gallons = 40,000 gallons daily = 13,600,000 gallons per year.

The expense at that rate is about 6½c per thousand gallons. The rate paid at Mattoon as mentioned was 17c per thousand gallons. It was a temporary supply however.

In order to make use of the banks formed around reservoirs by wasting the earth excavated, the dam at outlet in some cases has been kept high. This backs the water up in rear of reservoir, and unless there are banks each side of the inlet the water floods adjoining lands. If the reservoir is located in low, swampy or flat grounds, the water could not well be confined between banks in this way, and the consequent overflow would be liable to cause trouble. In such cases the following plan is suggested: Build a dam, designated for convenience a "retaining wall," at the inlet or point where the water enters the reservoir. This should be of the same height as the dam at the outlet where the overflow water is discharged. In this retaining wall build inlet boxes or pipes having slide gates or valves. If boxes are used, they should be placed one above the other, securely framed together and made water-tight. Wings should be extended into the retaining wall on each side, so that there will not be any possibility of the water forming a break in the dam at the sides of the inlet boxes. This furnishes an inlet for the water at various heights from the bottom of the inlet to the top of the retaining wall. The valves should be placed on the inside of the inlet next to the reservoir, and hinged on the top, so that they will swing in towards the reservoir. This will allow a free inlet for water coming to the reservoir. The valves should also be so arranged that when the backwater at the inlet is drawn off, the weight or force of the water in the reservoir will force them down or back into place and prevent the escape of the water in the reservoir. If pipes are preferred to boxes, they can be arranged in same way, being laid in mason work. In order to carry off the backwater at the inlet that causes trouble by overflowing adjoining land, lay an ordinary tile drain of the required capacity, beginning at the bottom of inlet and outside of retaining wall, then passing around and outside of reservoir, and ending at outlet, and outside of the overflow dam. The object of this drain as stated is to carry off the backwater. As soon as the rush of water subsides, the drain will begin to lower the water in question, which will cause the water in reservoir to close the valves in the inlet boxes and retain a full supply of water in the reservoir. · The time required to carry off the back water will depend on the amount of water and size of pipe, which can be ascertained and provided for.

Reservoirs are needed for mills or manufacturing purposes as well as for water supply on railroads, and would be very valuable for farm use in supplying water for stock, for growing fish, and for furnishing ice for summer use.

In farms where creeks or large ravines can be made use of, a reservoir could be constructed by simply building a dam, using earth from the proposed location for grading the embankment that forms the dam.

A very good plan for a dam, in such a location, is to set a row of posts in a trench dug crosswise of the stream, so that the tops will form the crown of the dam. The posts or logs should be dressed, so they will set close together. The tops of those in the center should be level for a distance of about six feet; then raise each way, to the banks on each side, forming wings to the dam. An enbankment is then formed on each side of this row of posts; that on the inside being graded to a slope of 1 in 3, and that on the outside about 1 in 15, or as long a slope as may be practicable. Then at the crown of the dam, on both sides of the posts, fill in and tamp solid as much stone as practicable. The row of posts will break the cutting force of the current at time of overflow, and hold the stone in place; and together with the stone will prevent any washing at the crown, which is the weak point in a dam or embankment of this kind. A dam built in this way at Crooked Creek, one of the water stations already referred to, has stood for years, while others that were previously built there of timber and earth failed.

When reservoirs are used for farm purposes care should be taken and measures adopted to prevent stock from getting into the water; for the water should not be allowed to become stagnant, and this can onlv be done by keeping it clean. If shallow water becomes filled with vegetable matter and other impurities it becomes stagnant.

Reservoirs should have steep sides, and have at least five feet of water when new. Trees and bushes can be planted near or on the banks, and although they will draw somewhat on the supply of water, still they will probably render an equivalent in the satisfaction and pleasure found in having at hand a veritable lake and park of one's own; and, if desired a row-boat can be added and a stock of fish supplied; and pleasures not often to be had on the prairie are at hand.

OIL AND NATURAL GAS IN ILLINOIS.

By THEO. B. COMSTOCK, Professor of Mining Engineering, University of Illinois, Champaign.

The attitude of engineers and investors alike towards the problem of the oil and gas resources of our state is a peculiar one. We are in a much better position than that of the earlier prospectors in the oil-fields of Pennsylvania, because we have the benefit of their experience and their inventions. So far as the practical difficulties of exploitation are concerned we need, therefore, have no fear but that we can manage them satisfactorily. On the other hand, we are not as yet in a position to demonstrate the extent and character of our supplies with that degree of certainty which is desirable as the initial basis of profitable industry. Capitalists are eager enough to engage in the mining of these commodities, if only they can be assured of the very probable existence of adequate supplies within reach of engineering skill, and we, as mining engineers, are fully able to guarantee the surmounting of every obstacle between us and the material sought, if we are informed as to its position, even remotely.

With affairs in their present condition, two diverse methods of attacking these problems may be adopted. First, the "hit or miss" plan of groping about all over the state, making test-borings in such localities as will furnish enough excited citizens to foot the bills, may result in some few finds, if the product be there and the funds be ample; but such a procedure will rarely bring us information of much permanent or extended application. It is a notorious fact that the percentage of trustworthy borings of this nature is extremely small, and unreliable records are much worse than none. Secondly, the careful study of the history of the development of other districts and the comparison of their geological and other conditions with those which occur in our own state, if properly done, cannot fail to place us in a position to determine at least the "expectancy" (so to speak) of unproved territory. In other words, a classified collection of local facts, studied in connection with results in fruitful fields, will enable the expert engineer to speak with some confidence concerning the prospects of discovery in special areas, whenever he can glean such data as are necessary for forming a judgment in any other mining operation. This is not saying that the necessity for test-borings will by this means be obviated, but it does imply that every

well authenticated *log* will acquire a new and a much magnified interpretative value, whether it be charged to profit or to loss in the ledger accounts.

At the outset of any such undertaking as this, it is always important to ascertain what grave problems concerning the subject are demanding solution—problems which, if solved, would settle the difficulties to a large extent. In this particular instance, there are so many questions awaiting answers, that it would be far more easy to state the little that is known than to enumerate the items expressing our ignorance. But we may profitably examine some of the conditions under which oil and gas are known to exist in other sections, making an attempt to determine whether we have any real grounds for hoping to unearth such treasures in Illinois.

ORIGIN AND RELATIONS OF PETROLEUM AND NATURAL GAS.

1. ORIGIN.—Whatever may be the opinions of geologists concerning the exact conditions necessary for the generation of these products, there are not many to-day who deny the probable connection of vegetable and animal decomposition with the result, although some facts may be, perhaps, more readily explained by theories based upon other known methods of generation.[1] Aside from this general unanimity, there is no close agreement among those whose investigations have entitled them to be considered as authorities. No one appears, however, to question the fact of the common ultimate source of oil and gas, their differences in physical properties being invariably regarded as due to environment or to successive stages in decomposition.

Leaving out of consideration the cause and source of the supply, there are two classes of theories regarding the place of origin. This, in the present stage of knowledge, is a question whose settlement is of the utmost practical importance. It is a very serious error to suppose that the working of our deposits will be the same if they have been produced where found as if the reservoirs have been filled from without. The theories which hinge upon the former hypothesis require for the existence of any considerable supply of *oil*, a much more extensive accumlation of bituminous material than our Illinois rocks propably contain at the proper horizons. On the other hand, while the theories of the other class do not necessarily make such demands, they do not help us much in certain other respects. The conclusion is a little less discouraging with respect to natural gas, but, in general, it must be admitted that we are ignorant of some of the most important facts upon which to base a thoroughly satisfac-

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1. Byasson states that petroleum is produced when water, carbonic acid, and sulphuretted hydrogen together act upon incandescent iron. Berthelot has also shown the possibility of the production of hydro-carbons by the action of carbonic acid upon the alkali metals under certain conditions which *may* exist in the interior of the earth. Mendeljeff believes none of the large deposits are of organic origin.

tory explanation of what we know. It will, therefore, be of little use to discuss the subject further in this place. We can do better by putting ourselves for the present into the position of one of the greatest workers in this field, Mr. John F. Carll, who remarks:[2]

> But there are so many unknown factors involved in a solution of these problems that we must be content to work slowly and—wait.
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> * * * * * * * * * *
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> There are strong arguments in support of both theories and they each have their earnest and distinguished advocates, but it is not an easy matter to prove either the one of them or the other to be universally applicable to facts as we find them. The probabilities are that we shall discover, when the subject is more thoroughly understood, that there is what might be called an indigenous oil in conformity to one theory and an exotic oil in agreement with the other.

Still, it is a fact of very great practical import that oil and gas are very closely related in general composition, in distribution (geographical and geological) and in their modes of occurrence. These relationships are far too intimate to be rated as accidental, and they do lend much support to the supposition of a common genesis; but too much stress laid upon this idea may cause us to be led astray in our search, particularly in new fields. There is another needed caution which applies even more forcibly to our own district. This is that we must guard against the common error of interpreting one boring by the *log* of another not in the immediate neighborhood. The neglect of this rule has heretofore sunk untold sums of money in portions of Pennsylvania in fruitless boring, and, in other cases, the most valuable deposits have been overlooked. In seeking coal in some places in Illinois the same mistakes have often been made. Startling as the statement may seem, in the greater part of the eastern oil and gas fields, as Mr. Ashburner remarks,[3] "No two wells can be put down, distant from one another but a few miles, where the same section of rocks may be found in both wells." From my own studies of borings made in Illinois, I am convinced that we must look for similar variations here in such portions of the state as can presumably be made to yield equivalent products.

2. Physical and Chemical Relations.—Many persons suppose that natural gas is of fairly uniform composition throughout the productive fields and that petroleum varies also within narrow limits. But quite the reverse is the truth. In Pennsylvania several varieties of oil are recognized, which are distinguished by peculiarities of color, specific gravity, viscidity and composition. Without enlarging upon these topics it may be simply stated that some of the petroleum obtained in the heart of the Bakou district, in Southern Russia, is light and limpid, easily volatile like naphtha, with little residue, but the impurities (heavier bitumens) increase and the color darkens as one proceeds towards the outskirts, becoming successively

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2. 2nd Geol. Surv., Pa., Oil Region III, pp. 271-2.

3. Chas. A. Ashburner, paper read before Amer. Inst. Mining Engineers, at St. Louis meeting, Oct., 1886.

yellow, green, reddish, brown and almost black. The famous Mecca oil, in Ohio, has a yellow color and high specific gravity. The Amber oils of Pennsylvania are more dark in color but of less gravity. Some of our far western oils are light green, quickly turning brown or black in the air. The heavier grades of the Pennsylvania product, like the yield of India, are dark green, brown and black. Italy produces a reddish yellow variety, and the Canadian output is often black and mal-odorous. In Wyoming Territory in 1873, the writer discovered pools of very heavy oil, which rapidly became converted into black asphalt upon exposure to the air.[4]

These differences are caused by varying proportions of admixture of different members of the Marsh-Gas Series of simple hydro-carbons. The lightest portions are the naphthas (gasoline, naphtha, benzine), all of which are of less gravity than the average of the whole, and may be readily distilled off and collected as liquids at a temperature below 100° F. The portions which contain larger percentages of carbon comprise the more permanent liquids (kerosene, etc.) used for illuminating purposes, the *lubricating oils* (of a buttery consistency at ordinary temperatures), and the solid *paraffins*. An average Pennsylvania oil will yield about 15 per cent. of the *naphthas*, 55 per cent. and upwards of *kerosene*, 15 to 18 per cent. of *lubricating oil*, 2 per cent., more or less, of *paraffine*, and 10 per cent. of *coke*, *gas* and waste. These products, it must be remembered, are the results of special methods of treatment in the refinery, and while they do not by any means compas the whole range of practical combinations, we need not go further for our present purpose of comparison. Some petroleums yield small proportions of the olefines (hydro-carbons of the Ethylene Series), and through such admixtures of the solid character we gradually run into the *pittasphalts* (mineral tar), thence to *asphaltum* (containing *some* oxygenated hydro-carbons in addition to the simple hydro-carbons), *cannel coal* (*rich* in volatile hydro-carbons), *bituminous coal* (volatile matter 15 to 45 per cent.), *anthracite* (volatile matter 3 to 7 per cent.) and *coke* (volatile matter less than 3 per cent.)

Natural gas differs from petroleum in a different way. Starting with the solid paraffins of the Marsh-Gas Series, by compression, congelation and the elimination of hydrogen, we get theoretically—and in great measure, practically—what we may roughly call the condensation series of products in about the order named above. Now, if we apply the principle of expansion, by heat or otherwise, we may reverse this process and cause the members to take up hydrogen step by step until we pass from paraffin to lubricating oil, to kerosene, to naphtha and on to *rhigoline* and *cymogene*, which are lighter and more volatile than *gasoline*, until, by appropriate means, we might

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4. Geological Report, Capt. W. A. Jones' N. W. Wyoming and Yellowstone Park Expeditions, 1873. By Theo. B. Comstock, Washington, Gov't Printing Office, 1875. Issued by Chief of Engineers U. S. A.

produce a gas so rich in hydrogen that we should be able to maintain it as Marsh-Gas itself at ordinary temperatures and pressures. Such, practically, is natural gas, and it may surprise some to learn that it is, after all, our dreaded enemy *fire damp* under another name.

I have thought it instructive to put before you a generalized table of the proportions in which the essential constituents—carbon, hydrogen and oxygen—enter into the composition of all our large natural accumulations of this kind, that you may realize at a glance how closely they are correlated:

TABLE OF PERCENTAGE COMPOSITION. (GENERAL).

PRODUCTS.	Carbon......	Hydrogen....	Oxygen......	Volatile Hydry-Carbons	Fixed Carbon..
Graphite....	98.+	.....	...	....	100.
Coke..	92.5	.....	4.	....	95.
Anthracite..	89.	3.5	3.	5. to 10.	90. to 95.
Semi-Anthracite..	.....	.....	...	15. to 20.	80. to 85.
Bituminous Coal	80.	5.	10.	20. to 35.	65. to 80.
Lignite	69.	5.+	20.	25· to 40.	60. to 75.
Cannel Coal	80.	6.	8.	40. to 65.	35. to 60.
Asphaltum	86.	9.	4.	70. to 82.	18. to 30.
Pittasphalt	86.	11.	3.	85.	15.
Paraffine....	85.	13.	2.	87.	13.
Petroleum	84.	14.	2.	90.	10.
Natural Gas	75.	25.	...	96.	4.

This table shows also the percentage of volatile matter and fixed carbon *in the combustible portion* of the various products. The classification adopted is, perhaps, not accurate, but it is as complete as possible in its present form and will serve our purpose.

Geographical Distribution.—Petroleum has been known for hundreds of years in China and other parts of Asia, as well as in Europe, but its use was quite limited until the present century. Now large deposits are commercially utilized in China, Japan, Burmah and Italy, also in Southern Russia, Germany and Italy. New Zealand furnishes a fair supply; Peru and other west coast South American countries yield it, and there is not a little in various localities in the West Indies. Canada and Nova Scotia have developed oil fields of notable value, although the product is usually less pure than the average.

In the United States, Pennsylvania leads in the production, followed by New York, Ohio, West Virginia, California, Indiana, Kentucky in about the order named, with deposits of prospective value in Colorado, Wyoming, New Mexico, Kansas and other states.

The general geography of the foreign deposits is of little import

for our purpose, and we can draw no very valuable conclusions from the mere geographical distribution in North America, except this—that in all the regions where oil exists in large quantity it does not occur in very mountainous districts, nor usually in the wide interior basins of the continents. This, however, is an extremely broad generalization, which can only be safely used by one familiar with the geological sub-structure. I have found good oil springs in the Rocky Mountain region at elevations greater that 7,500 feet above sea level, but always in basins somewhat removed from the rugged mountains, and invariably in situations, geologically considered, which conform to the rule here given. On the other hand, I know of workable deposits of oil which occur in positions seemingly non-conformable to the second half of the rule, but these may all be recognized as apparent rather than real exceptions, when the geological conditions are clearly ascertained. There is no petroleum east of the Allegheny Mountains. The geographical range of the natural gas fields is rather less restricted, but not enough so to make it probable that any large supplies can be obtained from regions containing none of the rocks adapted to the retention of oil. All the oil areas yield gas within or just without their confines, and such special belts as carry gas alone are just the ones in which oil has been sought with good prospects of success. We shall find that the conditions which determine the presence of one or the other or both are almost wholly geological. It is true that numerous gas springs and wells of inferior potency have been discovered in various districts, to which we cannot definitely assign any but the most superficial causes; but I know of very, very few cases of important or persistent gas pools in regions where oil could not presumably occur with but little change in environment.

None of the bitumens have been reported from Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Delaware, Maryland, Virginia, N. Carolina, S. Carolina, Georgia. Mississippi, Arkansas, Iowa, Wisconsin, Minnesota, Montana, Idaho, Washington, Oregon, Nevada; solid bitumens occur in Connecticut, New York, New Jersey, West Virginia, Texas, New Mexico, Arizona, Utah, California, Kentucky, Tennessee. But a map of the distribution of all the bitumens, with the oil and gas districts marked by special signs, will show that these areas have general trends parallel with the courses of the mountain chains more or less closely bordering one flank of each, and that the more readily volatile members run in narrow longitudinal belts through these tracts. These belts have a certain connection with the general topography in a limited sense; that is to say, they are defined by lines, or axes, of disturbance which originally affected the contour of the land, but subsequent changes of surface have well nigh obliterated the evidences of such structure from a geographical point of view.

4. Geological Range and Conditions.—Both oil and gas

come from so many different geological horizons in various parts of the world that the older theories which referred their origin always to one definite *locus* within the earth are now abandoned. For limited districts such a rule may be applicable, but it cannot be used as a guide in searching for these products in new territory. Even our eastern fields, which have so much in common as regards broad generalities, are widely at variance in local phenomena. So far as now known, there is no geologicrl formation above the Archæan in which, *under certain conditions*, gas or petroleum may not occur. This limitation to the base of the Palæozoic rocks is indeed slightly questionable if we admit the probability of some such genesis upon the large scale in nature as has been shown to be possible, and which has apparently occurred in the case of some volcanic petroleum products. But it is a fact that very few of the great geological groups of strata have been found free from petroleum in every part of the world. In Canada and in parts of Kentucky the Lower Silurian rocks probably yield the oil, and some small finds in Illinois appear to come from about the same horizon. In New York and Pennsylvania the Upper Devonian and Lower Carboniferous beds are the present sources of oil and gas. Higher formations have been somewhat profilic in other countries and along our Gulf border. In Colorado and neighboring districts the Cretaceous beds furnish the supply, and the Tertiary rocks have sometimes given a fair yield. Gas has been found all through the strata named and in the Glacial Drift besides.

With these facts in view, we cannot expect to settle the problems connected with our Illinois resources by the simple study of geological structure. We can, however, narrow the discussion very materially by first determining what conditions are necessary for the existence of such deposits in workable quantities. We know now that the occurrence of Silurian, Devonian, Carboniferous, or other strata in any locality does not indicate either the presence or absence of what we seek, even if we be working within the limits prescribed by our geographical rules. But are there not some characteristics of the known accumulations within the area including our state by which we may judge of the prospects here? If the deposits in the great belt of Western Pennsylvania and West Virginia have a definite geological horizon, why may we not expect a similiar position in Illinois? The reply to these questions is that the geological structure along the eastern edge of the belt differs from that of Illinois chiefly in the greater quantity and variety of the strata there, and in the greater elevation of much of that region above tide. We have somewhat the same structure, more simplified and somewhat deficient in the bituminous formations which abound there below the Coal Measures. But the Canadian oil basin and the Kentucky and West Virginia tracts differ in their characteristics from the Pennsylvania area, which fact may give us a little encouragement to hope that our section may not necessarily be dependent upon exactly the same features which the best known fields exhibit. We are a little more

liable to discover relations to some of the districts which are nearer to us, in Indiana and Kentucky; or we may be far enough removed to have a little independent manifestation of similar phenomena. Just how we stand in this matter, it is wholly impossible to determine from mere topographical considerations. The geologist can alone unravel the structure beneath the surface, and that this is not a simple task is shown by the lack of certainty upon this subject after many years of thoroughly good work by one who holds very high rank in the profession. I can emphasize my own estimation of the conduct of the Geological Survey by Dr. Worthen in no better manner than by stating that nothing whatever could be done today in discussing our local problems without the aid of his valuable maps and reports. What he has *not* accomplished is much less than most men would have left undone with the small sums at his command for the service. This state can well afford to extend this work until the detailed examination of its domain has made it possible to decide just where and to what extent our deposits of oil and gas exist. Private enterprise cannot be expected to make public the results of its investigations, and I venture as an engineer to remark that we cannot much longer hope to hold our position among the states without the use of gaseous fuel. If we must pipe it to our doors from abroad, it is time that we know it; if we have a supply of our own, as I hope to make appear reasonably probable, the state can well afford to expend the money necessary to prove it. We cannot afford to remain long in doubt.

Now let us consider what actual facts are in our possession and what legitimate deductions can be drawn from them. In this discussion I shall make use of all published papers within my reach, including the monograph by S. F. Peckham, in Vol. X of the Report of the 10th Census, 1880; the writings of Jno. F. Carll, Dr. J. P. Lesley, and Chas. A. Ashburner, of the 2d Geological Survey of Pennsylvania; the reports of the Geological Surveys of New York, Pennsylvania, Kentucky, Ohio, Indiana, Illinois, etc., and many special and technical papers published in various engineering journals and in the volumes of the Transactions of Engineering Societies. In addition to these some personal observations in the Pennsylvania, New York, Kentucky, Ohio, Indiana and Illinois bituminous areas, with studies of similar deposits in Colorado and Wyoming, together with an intimate field acquaintance with the geological structure of a large part of the region, have given me in the last fifteen years some little opportunity to form a judgment, such as it may be worth to you.

In Pennsylvania there are several oil horizons. The geological range is from the base of the Carboniferous to the Middle Devonian. In Canada and Kentucky the horizon is in the lowest Devonian strata. Southward in Tennessee and northwestward in Michigan and Illinois petroleum is found in Upper or Lower Silurian rocks. In southeastern Ohio the basal formations of the Coal Measures yield oil.

Where several oil-bearing horizons occur in a limited area, one fact is always apparent: the heaviest oils are nearest the surface. The Franklin (Pa.) dark oil is gotten from shallow wells, the Clarendon and Bradford amber oils come from wells from 1,000 feet to nearly 2,000 feet in depth. In regions yielding oil from only one horizon, the product is heavy or light, according to the depth from the surface, but the exact level is dependent upon geological features. Thus in Canada, at Litchfield, Illinois, and in other localities where comparatively little disturbance of the strata has occurred, solid bitumens, if any, will occur in the strata unless they be buried to a greater depth than in Pennsylvania. In Kentucky the wells are still deeper and naphtha occurs, while in West Virginia the same strata are below the oil horizons and yield only gas. Comparing the sections in Northwestern Pennsylvania and the Kanawha Valley we find similar results. The same rule holds good if we find bitumen beds below the oil-bearing levels. Going deeper in such cases we get gas. But as the oil in its reservoirs is often under great pressure, the boring of a well may cause an effect much like that of heating the mass (or of drilling deeper) so that gas may be encountered with the oil or even above it. The striking of a reservoir of heavy oil, like that at Litchfield, indicates the probable presence of lighter oils and gas at greater depths, *provided that the deposit be not itself in the lowest bituminous stratum.* But again there is a check upon us, for it rarely occurs that two highly productive reservoirs are struck by the same well. In other words, overlap is not common. For any given district there is a base line for oil, below which only gas can be found, if anything. Above that line, which is nearer or farther from the surface in proportion to the amount of disturbance of the strata, oil may be found in any rocks below 300 or 400 feet from the surface, if such beds be present as can furnish a supply. One more check confronts us, however. It is necessary that porous collecting beds covered by impervious strata should be present to confine the oil. Gas may be found at all points from the surface downwards as far as the deepest borings can go, if the above conditions be fulfilled.

Do we meet the proper conditions in Illinois? Roughly speaking, the answer must be, "*Yes, in a moderate degree.*" In the anthracite region of Pennsylvania, too much disturbance has occurred and the rocks are badly fissured and exposed on end to the atmosphere. Gas occurs there yet in the mines, but it is not confined in reservoirs under pressure and probably the *oil base line* is somewhere in the atmosphere, or practically nowhere. East of the Appalachians the bitumen horizons are far below any point which our drills can reach (about four miles). In Central Pennsylvania all are not within reach of the drill, but with a great development of the Devonian bituminous shales, the Silurian feeders are probably too deep to yield anything but gas. Besides this, the disturbance has been sufficient to give very favorable conditions and positions to the oil-bearing strata. As we go west the overlying strata have been eroded in

Northern Ohio, and there might have been no chance for reaching the oil deposits, if this denudation had not occurred. But the necessary heat has been engendered in connection with the Cincinnati anticlinal, which has elevated the strata as well. Had the same thickness of strata continued westward through Indiana and Illinois, without further disturbance, we would probably be in the condition of the Eastern States. But our danger is of exactly an opposite character. Too far away to be influenced much by the Cincinnati uplift, the strata thin out so rapidly in this direction that we are liable to have lost the very ingredients of the pudding. In Western Pennsylvania the Devonian rocks have a thickness of 1,000 to 1,500 feet; we have but 300 feet, which is about equivalent to the bituminous shales alone in the east. 50 to 100 feet will cover our black shales of that age.

Still, this is encouraging as far as it goes, and we have the further item that oil is known to occur in limestone of Silurian Age (Niagara Period) near Chicago and near LaSalle in the Lower Silurian (Trenton). Hence we need not despair, if only we can learn of some disturbances in the strata which may be supposed to have provided heat enough to drive off the lighter distillates or to develop an oil-depot in the bowels of the earth. As has been shown, the Cincinnati uplift is too far away and the Northwestern Ohio records only a step nearer. The recent developments at Muncie, Kokomo and Noblesville in Indiana are more tangible for us, but we need more evidence than this. If, as we know, our strata are thinner, and if no disturbance has occurred in our state to furnish the necessary heat, we are simply worse off than our eastern neighbors and must gauge our hopes to a point below their results.

By referring to the geological map of Illinois, and by studying the known facts as shown by borings, both successful and unsuccessful, in connection with the structure of the state as heretofore determined by Dr. Worthen, I think I shall be able to show that we do possess in Illinois a fair supply of natural gas and a modicum of oil, and that almost underneath our feet there is a mine which ere many years will be utilized as a better source of heat than what we are now using. My conclusion, here for the first time publicly announced, is the outcome of much study, and it is not in accord with preconceived ideas. I have had little faith in any permanent or deep-seated supply, and have always sought to check enthusiasm upon this point, but I had formed my opinions originally upon what, I must confess, was very superficial knowledge of Illinois geology. A residence of nearly two years within its borders, engaged in a pursuit which has brought me face to face with these problems in their practical aspects has made a radical change in my views.

Perhaps the facts may not be too familiar to you all, and they may here be briefly rehearsed. Referring to the geological map of Illinois prepared by Dr. Worthen, you will observe several lines of outcrop across the state, which indicate the axes of low anticlinals,

although some familiarity with the geology of the region is necessary in order to clearly understand the significance of the trends. The overlying drift deposits have very much obscured the substructure and we cannot affirm that our knowledge is by any means accurate. Until all the scattered records of borings have been collected and much more field work has been done, based upon strictly accurate topographical surveys, we shall be at a loss how to define the real boundaries of our gas belts. But enough is known to make a general estimate of the character and position of the more prominent areas.

Starting at the southeastern corner of the state, and passing northward, we soon come upon the culminating point of a prominent axis, which crosses the Ohio river near Shawneetown and the Mississippi near Bald Bluff, in Jackson county. Along this line, in Jackson, Williamson, Saline and Gallatin counties, the conditions for the production of oil and gas were prevalent, but the lower strata have been tilted so much, and thus exposed, that the prospects of discovering valuable deposits of this nature are not very great. Northward, in Franklin, Hamilton, White and Perry counties, the chances would seem to be better, unless deep borings shall reveal a condition of things not now suspected. In all this region salt springs are rather common, and there is much reason to hope that thorough exploration will yield favorable results in gas, although the statement must not be regarded as certain in the absence of a clear insight into the geological structure. So far as can be judged from our present knowlledge, there is not a very promising outlook for the next two or three tiers of counties northward, unless it be in wells of very great depth, but there seems to be another axis. approximately parallel (but probably turning farther northward at its eastern end), which passes across the country between Alton and Terre Haute in a course not yet fully determined. We must not commit ourselves too rigidly to this notion, for the facts are quite limited upon which it is based. But we have evidence of another prominent axis, presumably occupied by a fault, extending from the northwestern corner of Illinois in a very direct line southeast, passing not far from the towns of LaSalle, Urbana and Paris, crossing the Indiana line a little southwest of Terre Haute. North of LaSalle, the rocks which might supply the oil or gas are generally too near the surface to present the proper conditions for accumulation, but all over the area southward the evidences of valuable deposits of this nature are abundant.

Other uplifts, more or less coincident in direction with those we have outlined, are evident along the northern and western borders of the state. In none of them, however, are the conditions favorable, for reasons which will be readily apparent upon an examination of Dr. Worthen's map. Regardless of actual discoveries, from geological considerations alone, it may be asserted that important reservoirs of liquid or gaseous bitumens are *not liable to be discovered* in the counties of Alexander, Pulaski, Massac, Union, Johnson, Pope,

Hardin, Randolph, Monroe, Calhoun, Jersey, Greene, Pike, Scott, Brown, Adams, Hancock, Henderson, Whiteside, Lee, Kendall, Iroquois, Kankakee, Will, Carroll, Ogle, DeKalb, Kane, DuPage, Cook, Lake, McHenry, Boone, Winnebago, Stephenson, or Jo Daviess.

There is a *chance of discovery* in each of the counties of Jackson, Williamson, Saline, Gallatin, Perry, Franklin, Hamilton, White, St. Clair, Washington, Jefferson, Wayne, Edwards, Wabash, Morgan, Cass, Menard, Schuyler, Mason, McDonough, Fulton, Warren, Knox, Peoria, Mercer, Rock Island, Henry and Bureau.

The counties which *may yield oil or gas* at great depth, in situations not very favorable to development are: Clinton, Marion, Clay, Richland and perhaps a few others, but from present appearances the remaining counties are favorably situated. Of these, the conditions are especially good (presumably) in the counties of Champaign, Ford, Livingston, Edgar, Vermilion (west edge), Clark, Douglas, McLean, Woodford, Marshall, Piatt, DeWitt, Coles, Shelby, Montgomery and Madison, with, probably, other adjoining counties which can be included when their geology has been thoroughly worked up.

In presenting this classification, I do not wish to be understood as doing more than to outline the territory in the best manner possible with our limited information concerning the sub-structure of our own state. It is a crying disgrace that the means of settling this question has not been provided. We cannot hope to know positively what our resources are until our legislature is educated up to the point of providing liberally for the Geological Survey.

Turning now to the actual discoveries and their teachings we find that as early as 1854 the first discovery of oil or gas in Illinois was made about five miles north-northwest of Urbana, Champaign county. In digging for water, gas was encountered at a depth of 20 feet. In 1865, petroleum was discovered in small quantity in a well near Chicago, in Niagara Limestone. This rock is too near the surface in Cook county to make the deposit economically important. In 1873, another incidentally discovered gas well was opened two and one-half miles south of Champaign, at a depth of 65 feet. This is upon the farm of H. J. Dunlap, present editor of the *Champaign Gazette*, and, like the first one mentioned, is still used for household purposes. Since that date several similar wells, none over 90 feet in depth, all in the drift deposits, have been struck in Champaign and adjoining counties, The pressure per square inch is about thirty pounds, or less. All these wells, besides numerous other indications of the presence of natural gas, lie along the LaSalle-Terre Haute axis previously indicated, and all other reports which have reached me seem to bring the discoveries wholly within the range of this and what I have roughly denominated the Alton-Terre Haute axis.

Petroleum (heavy lubricating oil) and abundant snpplies of gas have been discovered at Litchfield, Montgomery county, and very small amounts of the former have been taken from a mine at Mattoon. I am constantly receiving reports of similar discoveries of great-

er or less importance from various points within the territory marked out in these pages. If future investigations shall extend or narrow the boundaries of the productive area, it will be because our present ideas of the geology of the state are erroneous.

If we study the subject further we shall learn that our best chances of success are exactly in those places in which fire-damp is most abundant in the mines. In 1885, Mr. John Fulton, of Johnstown, Pa., called attention to the prevalence of this gas in the mines of that section, and he concluded that this was an indication of the existence of a liberal supply there for economic purposes. In his paper[6] he clearly showed the exotic origin of the gas, and there is now little doubt that our supplies of this material do not come directly from the coal. More than this, the mines of Illinois in which fire-damp does not occur are in districts which give no hope of yielding supplies of natural gas, and my own observations convince me that the greatest amounts of fire-damp are given off over the area herein indicated as the most favorable for our purposes. I have met this gas at Sidney, Champaign county, at the depth of 365 feet, and it occurs frequently in other places, as at Paris, Marshallville, etc., even when unsuspected by the miners, as has been shown more than once of late.

Many still hold to the idea that the deposits along the LaSalle-Terre Haute axis are nearly local, being derived from the decomposition of a bed of peat some sixty feet below the surface. This explanation was satisfactory to myself until I had investigated the facts. Now I am fully convinced that this view is quite untenable, and for the following reasons:

First, the pressure of the gas increases after passing below the peat bed and it has been found at much greater depths.

Secondly, there are considerable local variations in the character of the peat (from mere black soil to veritable peat) and there are no corresponding variations in the quantity of the gas, but sometimes there is no gas where the peat occurs and a great abundance where the common soil is found.

Thirdly, the gas follows structural lines in the strata beneath the drift rather than the local distribution of the peat-bed.

Many minor features of denudation and subsequent deposition are only partly worked out in the state, hence we are much more liable to be correct in stating where gas cannot be found than in our list of favored localities.

In the water works well at Urbana, gas is evident and its abundance is variable, depending largely upon conditions of atmospheric pressure. Near Paxton there is a peculiar small area of spouting wells, which has never been satisfactorily explained. I see no reason to doubt that gas is the propelling power, and very likely a similar

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6. "The Source and Behavior of Fire-Gas in the Johnstown Mines," Trans. Amer. Inst. Mining Engineers, Vol. XIII, p. 772.

cause gave rise to the almost irrepressible Iowa fountain, which created the great sensation some months ago.

Since taking up this subject many facts have come to my knowledge and the strongest support to the views here expressed is found in the almost unanimous correspondence of new discoveries with the predictions as to locality. Many wells are projected in the most promising fields and we may soon hope to know much more than we do now. The state of Illinois can well afford the most liberal expenditures upon such investigations as have already been made in Pennsylvania, Ohio, Kentucky and other states. Meanwhile every well authenticated fact is of value, and the writer earnestly requests that he may be favored with such details as may come within the observation of the members of this society. I am indebted to some of you already. The facts are, of course, much more numerous than those here quoted, but their lesson is the same and it will not be necessary to give them in detail. Gas has been reported from almost every county along the two principal axes of uplift, although but little use has been made of it as yet, except in Champaign and Montgomery counties. At Litchfield it exerts very high pressure and its utilization is quite thorough. There is no reason why other towns should not be supplied from home sources, and it is probable that manufacturers in the largest cities will eventually be able to avail themselves of the accumulations in the central portion of the state by means of pipe lines. Those who show the greatest zeal and enterprise in the matter will reap the richest reward. Judicious boring near Urbana will most probably be successful, but it will be necessary to perform the work carefully, to exclude water as much as possible from subterranean sources and to preserve records, giving strict attention to every detail that nothing may be overlooked.

DISCUSSION.

The President.—The many members present may know of wells or indications of natural gas or oil in their immediate vicinity not generally known throughout the state. It would be of interest to hear from them.

Mr. Bullard—I had the pleasure of a visit to Litchfield in the month of October last. The first intimation of oil in that region was noticed at the bottom of a coal mine. The water pumped from the mine was noticed to have oil mixed with it. A well was sunk by the coal company near by the mine to a depth of 40 or 50 feet below the shaft when a fair production of oil was obtained—something like four barrels a day. Salt water was found with the oil. Other wells were sunk with less success. The oil attracted the attention of eastern men who were familiar with the Pennsylvania productions. Other wells were sunk to a greater depth—800 or 900 feet below the

surface—when natural gas was found in great abundance, in one instance under a pressure of 500 pounds to the square inch. I was told the pressure now stands at about 400 pounds. The gas was conducted into the city and is now largely used for fuel by the citizens. The gas is a strong heat producer but is indifferent in the production of light.

Mr. ———.—Natural gas has been found in wells near Pontiac which still are burning.

Mr. Burt.—There are one or two wells in the lower part of Bureau county. Am not much acquainted with it myself. I only know it has been used for several years.

Mr. Hill.—There is a mine half way between Terre Haute and Indianapolis where traces of the gas are noticed. The mine is not troubled with fire-damp, but a sort of gas accumulates in holes in the top of the mine. There are some also between Greenville and Terre Haute.

Mr. Alkire.—There is a little station on Chicago & Alton railroad south of Bloomington which has a mine having I believe natural gas. One day in the mine we noticed a bubbling in the water which lay four to six inches deep in places on the bottom. We held our lamps above the place and were treated to an explosion. The borings a mile north of there showed a depth of one hundred feet to the coal measures. One hundred and sixty feet reached quicksand.

Mr. Comstock.—In regard to the presence of salt I will say that salt water is almost always found accompanying these products. It may be that beds which contain salt water are more porous and therefore afford better facilities for storing and conducting the gas, but there is probably also some relation between them not yet fully ascertained. Natural gas is not usually good for lighting purposes. At Findlay, Ohio, owing to poor manipulation the light would vary in intensity at times. The failure there could not be laid to the gas, though the gas has not enough carbon in it to make it serviceable for lighting in ordinary burners.

RAILWAY TRESTLES.

By EDWIN A. HILL, of Indianapolis, Ind.

Temporary or permanent.—In building railways a ravine or bottom can often be crossed much cheaper with a temporary trestle than with an embankment; but when the line is built, and the time arrives for renewing the trestle, it may then be cheaper to fill than to rebuild. On the other hand, there are always cases where extreme height makes embankment an expensive luxury, or where a waterway or passage way must be kept open below the grade of the road, making filling out of the question, and here the trestle work must be always maintained. Hence, railway trestles are naturally divided into the classes, temporary and permanent.

Whether in a given case we should adopt an embankment, a temporary or a permanent trestle, involves a comparison of their respective costs. As between embankment and trestle work, the latter can be quickly constructed, and is often used when time is an object, or because it is cheaper. In such cases it is usually intended to replace the trestle with earthwork after the completion of the road, when filling can be done for less money, owing not only to increased facilities for handling and transporting material, but also to the fact that by the time the trestle needs renewal the cuts and ditches usually need cleaning out, and this material becomes available for filling purposes.

Assuming the average annual expense of maintaining a wooden trestle at one seventh of its first cost, which is 5 per cent. interest on a sum equal to about three times its first cost, then evidently we are justified in building embankment, or temporary trestle and embankment, costing three times as much as a permanent wooden structure.

Our comparison will then be between:

1st. The cost of an embankment.

2d. The cost of a temporary trestle plus the cost of filling after completion of the road.

3d. About three times the cost of a permanent wooden structure.

4th. The cost of a permanent iron structure.

Whichever plan is in the long run most economical should be adopted, though we are always justified in incurring a reasonable extra expense, if thereby we can substitute embankment for trestle, particularly so, when funds are available and high-class work is called

for. Where, however, cheapness in first cost is a "*sine qua non*," the temporary structures, though eventually the dearer, must be adopted because they cost less now, the policy of the management being for the future to care for itself.

Permanent trestles are mostly confined either to lofty structures or to structures over marshes, rivers, ponds and bottoms subject to overflow, or over railways or highways. Vose says that, "The height at which a trestle becomes more economical than an embankment depends much on local conditions affecting the price of earthwork, and ranges from 25 to 50 feet." High trestles are usually iron structures, and when built of wood are the subject of special design; neither can be properly treated within the limits of this paper. I shall therefore confine myself to the subject of pile and frame trestles of moderate heights.

The several bents which support the stringers of a trestle correspond to the piers of a bridge supporting its several trusses. These bents may be of piles, properly braced; or a frame-work of timber resting on suitable foundations, forming respectively, the two well-known types, pile and framed trestles.

Pile Trestles.—The number of piles per bent varies from two to six, but less than four is not good practice. The proper number depends upon the load sustained, varying with the span which for moderate heights is rarely over 16 feet from center to center of bents. In the west 15 to 16 feet between centers and 4 piles per bent is ordinary practice, while on eastern roads 12 feet is the usual span and 6 piles per bent are sometimes used. The ordinary range of practice is from 4 to 6 piles, diameter from 10 to 18 inches, spaced from 12 to 16 feet from center to center.

Sustaining Power of Piles.—In the following formulæ

D, (inches) = Diameter of large end of a round pile.
d, " = " " small " " " "
h, (feet) = Height of fall of ram.
s, " = Last penetration of pile.
s_1, (inches) = " " " "
C, (pounds) = Crushing strength per square inch of pile timber.
w, " = Weight of ram.
p, " = " " pile.
L, " = Safe load per pile.
L^1, (tons) = " " " "
f, = Factor of safety.

TABLE OF FORMULÆ.

Sought.	Weight of Pile Considered.	Weight of Pile Neglected.	
	Weisbach and Mason.	Weisbach and Sanders.	Sager.
L=Safe Load.	$L=\frac{w^2\,h}{s(w+p)f}$	$L=\frac{w\,h}{f\,s}$	$L'=\frac{\sqrt[3]{h}\times\frac{1}{40}w}{(s_1+1)f}$
s= Last penetration in ft.	$s=\frac{w^2\,h}{L(w+p)f}$	$S=\frac{w\,h}{L\,f}$	
s_1 =Last penetration in inches.			$s_1=\frac{\sqrt[3]{h}\times\frac{1}{40}w}{L'\,f}$
f =Factor of Safety.	$f=\frac{u^2\,h}{L(w+p)\,s}$	$f=\frac{w\,h}{L\,s}$	$f=\frac{\sqrt[3]{h}\times\frac{1}{40}w}{(s_1+1)\,L'}$

ORDINARY VALUES OF f.

In crushing formula, f = 10	f = from 6 to 10	f = from 7 to 12	f = from 2 to 5

For safety against crushing we must have $L < (D^2+d^2)\times\frac{.3927C}{f}$

CONSTANTS FOR CRUSHING STRENGTH OF PILES.

TIMBER.	Crushing strength lbs per square inch.	Value of $.3927C$.	Logarithm $.3927C$.
Red and White Ash and Elm........	6800	2670.2	3.426511
White Cedar........................	4400	1727.9	3.237544
Chestnut and Hemlock..............	5300	2081.3	3.318272
Black, Red and White Oak and Beech	7000	2748.9	3.439175
Scrub Oak, Red Cedar & Buttonwood	6000	2356.2	3.372175
White Pine........................	5400	2120.6	3.326541
Red or Norway Pine................	6300	2474.0	3.393400
Pitch Pine........................	5000	1963.5	3.293141
Georgia Pine......................	8500	3338.0	3.523486

The preceding formula for crushing strength is modified from one given by Mr. Hering, and f should not usually be taken less than 10. The above table of Constants is based on Trautwines' data, and will facilitate computations. In all ordinary cases, however, piles are amply safe against crushing.

The formulæ of the preceding table apply only when the pile is sustained solely by the lateral friction of the soil. When driven to a solid foundation such as rock or hard pan, the safe load should be found by the rule for the strength of columns.

The various formulæ for the sustaining power of piles give somewhat conflicting results. Formulæ based like the above on the last sinking of the pile under a known weight falling a given distance are considered the most reliable. Mr. Sager's formulæ were submitted to this society last year and closely resemble those of Trautwine, who takes exceptions to Sander's formulæ. Trautwine's remarks on this subject and Mr. Sager's paper on pile foundations can be consulted with profit; and particular attention is called to the pamphlet of Mr. R. Hering on "Bearing Piles," where a good comparative summary of all the principal formulæ will be found. Mr. Hering recommends Mason's and Sander's formulæ, preferring the former. In general, he advises f taken at from 3 to 5 for temporary work, from 6 to 10 for heavy work, especially in clayey soils, and when bents are subjected to vibration and for very important cases or unreliable ground still higher values. Sanders, he considers the least reliable and I think should be used with higher value of f. In ordinary trestles for railways, with Mason's formula, f should not usually be less than 8 or 10. In this formula the value of p can be computed from Trautwine's data. Generally, round piles, as they average in trestles, will vary in weight from 20 to 50 pounds per lineal foot depending upon kind of timber, dimensions, and whether green or well seasoned.

In Sager's formula f varies from 2 to 5, the latter value being suited to railway work. Mr. Sager remarks that no rule correctly applies to all conditions and circumstances, but considers his own a fair average rule for the majority of cases. The rules are usually unreliable in mud and quicksand and in clayey or other soils readily affected by water.

The preceding formulæ only carry us to the surface of the ground. Above the surface the ordinary rules for the strength of columns apply, and the pile may be regarded as a column having a pin bearing at the ground line and a square end bearing at the cap.

Driving Piles.—In driving piles a heavy ram with a short fall gives the best results. The fall should not be over 40 feet and preferably much less. On my own road we drive to a 2-inch penetration under 20 feet fall of a 2000 pounds ram. Clayey soils, especially where very wet or liable to become so, require a very large factor of safety. Elm and spruce are considered the best material, but in

western practice oak and other timber are extensively used with good results.

In planning new work, it is often advisable to either make soundings or borings or drive test piles to determine the nature of the soil and calculate the necessary lengths to be used. Many additional formulæ will be found in Mr. Hering's pamphlet covering this and other related points, to which all are referred for further data.

Increase in the Rolling Load.—The mathematical instinct would prompt one to calculate the exact sustaining power of the bent, and its probable maximum load, but in inspecting existing trestle work we rarely have any data showing the last penetration of the piles, and in construction it is useless to speculate too closely as to what rolling loads the future may bring forth. Not long ago the strains in bridges were computed with painful minuteness, but the recent drift of opinion is tending away from useless refinement in the computation of bridge strains. Bridge after bridge all over the country, each carefully proportioned to strain sheets figured out with the most scrupulous exactness, has been replaced by a far heavier structure, because of a constant growth in the weight of motive power and rolling stock, which has been going on regularly for years past, and still the end is not yet. Not many years since we were talking of 1,500 pounds rolling load, and later of 2,000, and then 2,240, while to-day our leading railroad journal is advocating for computation of strains in long spans the use of a concentrated load of 50,000 pounds, followed by a rolling load of 3,500 pounds per lineal foot.

Some idea, however, of the present and probable future loads can be derived from the following table taken from the Illustrated Album of the Phœnix Bridge Company, which sufficiently indicates the heavy rolling stock now in vogue:

Road.	*Type.*	*No. wheels or drivers.*	*Wheel base.*	*Total weight on wheel base.*
P. & R.	Coal Car	8	4′10″	39,000 pounds.
P. R. R.	Gondola Car	8	5′0″	30,000 "
P. & R.	Passenger Car	8	5′4″	30,000 "
P. & R.	Passenger Engine	4	7′0″	68,000 "
P. R. R.	Passenger Engine	4	8′0″	80,000 "
Cent. Vt.	Mogul Engine	6	16′6″	94,000 "
P. R. R.	Pusher Engine	6	10′8″	89,000 "
P. & R.	Consolidation Engine	8	14′9″	90,200 "
P. R. R.	" "	8	13′6″	96,000 "
P. R. R.	" "	8	13′10″	100,600 "

Shearing Stress.—In trestles of not over 16-foot span, to which this paper is mainly confined, the bent probably receives its greatest stress when the second pair of drivers of a heavy consolidation engine comes upon it. This stress, in bridge parlance, is termed the "shear," which for trestle bents is equal to the weight of the bent together with one span of the track and stringers, plus any load directly sus-

tained by the bent, plus the shearing stresses coming respectively from the right and left hand trestle spans.

In Figure 1 let A and C represent the caps of two trestle bents, and let LL′, drawn to scale, represent any load sustained by the stringers. Then by the law of the lever, the shear, or portion of the load sustained by C, is equal to $\frac{\text{LL}' \text{ in pounds} \times \text{L A in inches}}{\text{A C in inches.}}$ and if we take LS=AC and join L′S, then CC′ by scale equals the stress on C in pounds.

In figure 2, extending this principle, A, B and C are the caps of trestle bents and LL′ and ll′ respectively the loads on the forward driving axle and pony truck axle of an engine; then since the load on the right hand exceeds that on the left hand span, as the engine moves from right to left the shear on C coming from LL′ will increase faster than that coming from ll′ will diminish, hence the combined shear on the cap C will be greatest when LL′, the greater load, arrives at its right hand edge.

Fig. 1

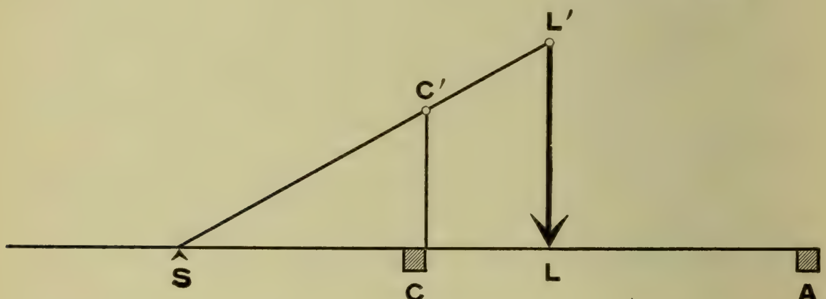


Fig. 2

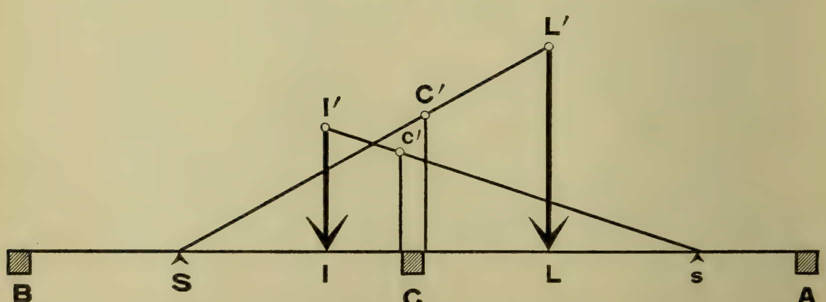
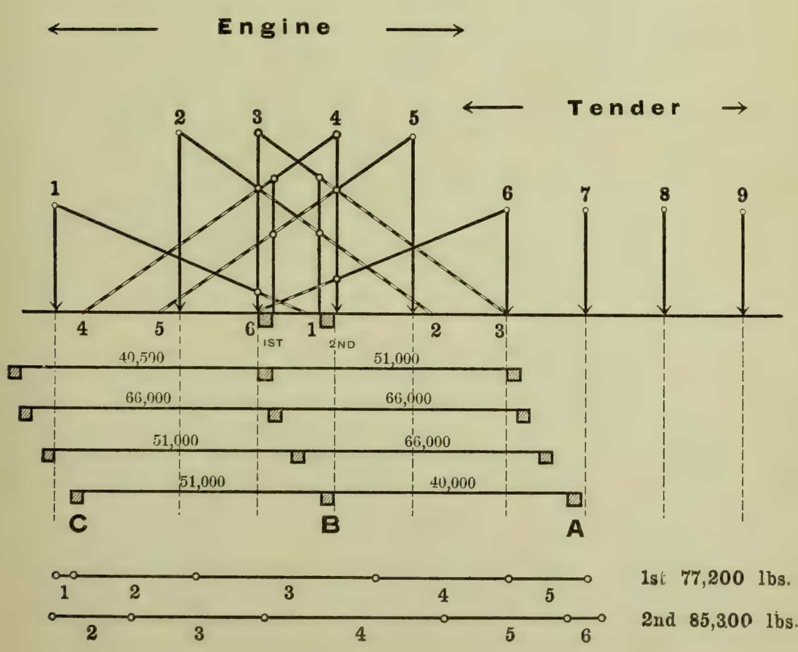


Figure 3 represents in magnitude and position the loads on the wheels of a typical consolidation engine and tender as used by Professor DuBois in his work on "*The Strains in Framed Structures.*" If now we conceive this system of loads substituted for the two loads L L^1 and l l^1 in Figure 2, then, as our consolidation engine advances from right to left, the shearing stress on B will increase until the sum of the loads on the left span becomes equal to or greater than the sums of the loads on the right span, which occurs when load 3 is just over the left edge of the cap, B as shown in the figure. Should the engine now move farther to the left, we should have 66,000 pounds on each span, and the shear on B would not be changed until load 4 passed off from the right hand span. We would now have 66,000 pounds on each span, and a further movement to the left would not effect the shear until No. 1 passed off the left span, leaving a preponderance of weight on the right span, so that a further movement to the left would increase the shear on B until load 4 came over the right hand edge of B. These several positions of the load and span are shown in the figure by the several drawings of the caps

Fig. 3



below the diagram of loads, and for convenience we suppose the trestle to be shifted from left to right under the engine, instead of the latter moving from left to right over the trestle.

In practice, however, the several positions giving the greatest shear on B are best found by drawing the two trestle spans with caps on a separate sheet of paper and sliding this along just below the diagram of loads.

The remaining construction is identical with that of Figure 2. The cap B is drawn in the two positions giving the maximum shear and the several components of the shear in each case summed up on the two parallel lines at the bottom, from which we see that the second position of the load gives the greatest stress on the bent, corresponding to 83,500 pounds. Assuming track and stringers at 375 pounds per lineal foot and we have an additional weight of $375 \times 16 = 6{,}000$ pounds, or in all 89,500 pounds stress on the bent.

There are already on some roads engines producing even greater stresses than this, so that in extreme cases from 90,000 to 100,000 pounds on a trestle bent of 16-foot span would not seem an excessive allowance, bearing in mind the tendency for engines and cars to constantly grow heavier. On the other hand, there are many roads where heavy consolidation engines are not in use, nor likely to be introduced for some years—probably not until a projected trestle has been entirely replaced once, twice, or even more times.

We should not look farther ahead than the probable life of the structure we propose to build, or seven to ten years in the case of a wooden trestle; but in the case of a permanent iron structure, we must, of course, make a much more liberal use of extra material, striving to discount the future as far as possible, for once built it can not be readily strengthened. With wooden structures it is different, but even then we should base our plans not exclusively on existing loads, but with a view to providing against probable increase in loads during most of the life of the structure. Hence for trestles we should increase present loads by a reasonable percentage to cover future contingencies.

Those familiar with the methods of graphic statics will have no trouble in computing both the shear for trestle bents, and the bending moment for track stringers. The methods suggested in this paper while analogous thereto, possess some novelty, but such as have better ones at command can of course employ them. As a general rule, we may state that *the stress on any bent is the product of the load into its distance from the other bent and divided by the clear span.*

In inspecting existing trestle work we should determine from the actual rolling stock in use the maximum shear on the bent, add the actual weight of one full span of track and stringers, and divide by the number of piles, the result being the stress on each pile. Should this be less than 15,000 pounds it is probably safe enough, unless the piles are unusually deficient in sustaining power; but the more this figure is exceeded the less confidence we should place in the

structure, except we have some definite record of the actual performance of the piles when driven. In default of such information, it might be advisable in important cases to uncap a bent here and there and observe the actual penetration of a few piles under one or two blows of the ram, and if we find this running pretty uniform we may apply the values of s, h, and w in Mason's formula and by working out the value of f, the factor of safety, see how we stand.

Sway Braces.—Trestles are subject to lateral stresses, owing to the side lurching of trains under high speed, and on curved trestles to centrifugal force; and also to longitudinal strains, owing to the tractive force exerted by the drivers of the engine.

The resistance of the track and stringers to buckling sideways partly opposes this latter force, and in pile trestles, unless of unusual height, the transverse strength of the piles also offers an efficient resistance.

The former strains are resisted mainly by the diagonal lateral bracing, consisting usually of two pieces of 3-inch plank one foot broad, spiked, or better still bolted by $\frac{7}{8}$ or 1 inch bolts, to the cap and to the piles at each intersection. Each additional pile in the bent, it will be observed, affords two more intersections for bolting, and, besides increasing the bearing value of the bent, renders it stiffer and better able to sustain the lateral thrust of the moving train.

Two and Three Pile Bents.—Two pile bents are quite deficient in sustaining power and lateral stiffness, even in bents spaced only 12 feet between centers. Three pile bents though better have none too much stiffness and bearing value.

Four Pile Bents.—Four piles afford a bent with still more sustaining power, and one more efficiently braced against lateral stress, and this number is therefore to be preferred. Such bents spaced 16 feet from center to center are used by many western roads, and while often deficient in bearing value where consolidation, mogul, or extra heavy four-wheeled locomotives are in use, answer very well for roads of medium traffic.

In the four pile bent the usual arrangement is either to have the track stringers bearing over or near the inner pain of piles, or else to group two piles under each set of stringers; but piles can not be driven exactly in line or at exactly equal distances apart. In practice they are driven as near to their proper position as possible, and then a cap sometimes 12″ × 12″ but better 14″ × 14″ because giving the stringer more end bearing and from 10 to 16 or more feet long is placed upon them.

It was long the custom to secure the cap to the piles by mortise and tenon, drawing the cap down to its seats by a wooden pin, but modern practice avoids all cavities and crevices where water can collect and start decay, and we now usually find the piles sawed square off at top, and the cap secured to each pile by a drift bolt usually $1\frac{1}{4}$ inches in diameter and long enough to drive about 8 inches into the pile. Sometimes two smaller drift bolts are used instead.

Framed Bents.—The framed bent is of different construction. It is usually composed of 12″ × 12″ timbers, and in its most ordinary form consists of a sill into which is secured usually by mortise and tenon two upright or plumb posts placed directly under the track stringers, two batter or inclined posts, one on each side of each plumb post, with a 12″ × 12″ cap supporting the stringers. Sometimes the batter posts have square ends let into the sill and are secured thereto by iron straps. The usual batter is about 3 inches per foot. The forms of framing differ greatly, varying with the height, distance between centers, character of traffic, and the ideas of each constructor. The object sought is to form a rigid framework of timber strong enough to sustain the weight of the train and properly stiffened against lateral stresses, and the result is reached in various ways.

The calculation of stresses and dimensioning of pieces calls for no special remark. 12″ × 12″ sticks are usually used for the principal members of the frame, 6″ × 12″ sticks for longitudinal bracing and 3″ plank for sway bracing.

Framing may be by mortise and tenon or instead we may use two 3″ dowel-pins to each post. Where mortises occur the tenons should vary from about $\frac{1}{4}$ to $\frac{1}{3}$ of the width of the timber and the pin holes should be bored so as to draw the cap or sill about $\frac{1}{8}$ of an inch. Drainage holes should be bored to the mortises to prevent water from collecting therein.

The lower member or sill of the framed bent should rest on a suitable foundation. I have nothing but disapproval for the practice of placing sills in a shallow trench and then partially covering them up with earth. Mud sills or timbers 4 to 6 feet long, bedded in the earth at right angles to the sill as a fonndation for it, are an improvement, but not all that could be desired. Better practice places the sill on a foundation of piling, stone blocks, or on some not too expensive form of masonry.

Corbels.—Sometimes the stringer ends rest directly upon the caps, and sometimes we find a "corbel" interposed between the cap and the stringer. Concerning corbels there is some diversity of opinion, but the question becomes more important as the structure increases in height and span. In favor of them it is urged that the clear span can be reduced by about the length of the corbel. thus enabling lighter stringers to be used with equal safety, and also that they afford more end bearing to the stringers. Those who object to them say that they are extra and unnecessary pieces in the structure increasing both labor and quantity of material; that the end of the corbel is a fulcrum, on which the stringer pivots in its deflection, causing upward motion over the cap thus tending to unnecessary strain and disarrangement in the stringer system; that by collecting moisture at the stringer ends they lead to early decay in the most vital part of the structure; also that the stability of the structure is impaired in so far as the center of gravity of the train is raised by

them higher above the cap, which is always a firmer support to the stringer than any stick of timber interposed between them. For myself, while not greatly in favor of corbels, I do not consider the question as entirely settled, and should be glad to have an expression of opinion on the subject.

Stringers.—We pass now to the stringers. They vary in depth from 12 to 18 inches, though 16 inches is a very common depth. We may find either one, two or even three grouped under each rail, with or without outer or "jack" stringers.

Evidently if several stringers are placed side by side in contact with each other, moisture will collect between them, and rotting will soon set in. To avoid this they are always spaced from one to three inches apart, the spaces being preserved either by wooden packing blocks, or better still by suitable devices of iron which having less area are less liable to gather moisture. Some roads use an iron block, dimensions 1″ x 3″ x 1′; others a cast iron spool; and still others simply two ordinary cast washers placed with their flat sides against the stringers and their convex sides in contact.

Whatever device be employed, whether wooden or iron blocks, iron spools, or washers, the stringer bolts, which are usually $\frac{3}{4}''$ in diameter, though sometimes larger, and which serve to hold together the group of stringers, pass directly through the stringers and also the spacing blocks or spools. Four bolts to each joint is the present practice. Where possible a stringer in length double the distance between the bents should be used, in which case the stringers when arranged in groups of twos are laid to break joints, each joint being central over a cap, stringer bolts and spacing blocks being used at the center and at each end of each stringer, and occasionally also at the center of span half way between the bents.

To secure the stringers against shifting laterally or longitudinally, each stringer continuous over a cap should be drift-bolted thereto, or otherwise secured in place. In some trestles heavy blocks of wood are spiked, or iron angle plates are bolted, to the cap on each side of the stringer; again, the wooden key used for spacing the stringers is let into the cap; and sometimes the stringers are also boxed into the cap, or their ends notched down on it. Drift-bolting to the cap however avoids cutting the cap or stringer and is good practice. The bolts should be about $1\frac{1}{4}$ inches in diameter and extend not less than 8″ into the cap.

Jack-Stringers.—Where outer or jack-stringers are used they are generally designed to come into play mainly in cases of derailment by affording a support to the ends of long ties, the stringers directly under the rail being relied on for carrying the train. Jack-stringers, besides entailing considerable extra expense for labor and material, are in the way when replacing track stringers, and are not always in favor with the road department, though of good service in case of accident. My own preference is for a wide floor system and double guard-rail.

Formulæ for Track Stringers.—In the following formulæ:

W, (pounds) = assumed maximum center load.

S, " = maximum shear at any point in the stringer.

s, " = weight of stringers, track, etc., for one span, which when unknown may be roughly assumed at 375 pounds per lineal foot.

$w' \; w'' \; w'''$ etc. (pounds) = loads on the several axles of the rolling stock.

$a' \; a'' \; a'''$ etc. (inches) = distance from said loads to edge of nearest cap.

b, (inches) = combined breadth of all track stringers.

d, " = common depth " " "

l, " = clear span " " "

c, " = width of cap.

C_1 (pounds) = Constant for transverse stress.

C_2 " = " " shearing "

C_3 " = " " end crushing.

f, = factor of safety.

Data for Weight of Trestles per Lineal Foot (Approximate).—The weight of timber is taken at 3 pounds per foot B. M. The weight of rails equals two-thirds of the number of pounds per yard. All values are given per lineal foot of track.

	Weight in Pounds.
Rails	From 37 to 50
Spikes, splices, bolts, nuts, washers, etc.	" 6 " 9
Ties, 8″ x 6″ — 9′ = 36 ft. B. M., spaced 18″, 24 ft. B. M.	" 72
" 8″ x 7″ — 14. = 65 ft. B. M., spaced 12″, 65 ft. B. M.	" 195
Guard-rails, 2 sticks 6″ x 6″, 6 ft. B. M.	" 18
" 4 " 8″ x 7″, 17 ft. B. M.	" 51
Stringers, 4 pieces, each 6″ x 14″	" 84
" 6 " " 7″ x 14″	" 147
Cap, averaged at from 12 to 16 ft. B. M.	" 36 " 48
Total weight per lineal foot of span	" 253 " 500

$$\frac{S}{2} = \text{from 125 to 250 pounds} \times \text{clear span in feet.}$$

FORMULÆ FOR TRACK STRINGERS.

Dimensions in inches. Loads in pounds.

$$W_1 = W + \frac{s}{2} \qquad S_1 = S + \frac{s}{2}$$

	Sought.	Tranverse Stresses.	Shearing Stresses.	Crushing at ends.
For New Construction.	b = Least breadth.	$b = \frac{W_1 l f}{C_1 d^2}$	$b = \frac{S_1 f}{C_2 d}$	$b = \frac{S_1 f}{C_3 c}$
	d = Least depth.	$d = \sqrt{\frac{W_1 l f}{C_1 b}}$	$d = \frac{S_1 f}{C_2 b}$	Not limited by end crushing.
	l = Greatest length.	$l = \frac{C_1 b d^2}{W_1 f}$	Not limited by shearing stress.	Not limited by end crushing.
	c = Least width of cap	Not limited by transverse stress.	Not limited by shearing stress.	$c = \frac{S_1 f}{C_3 b}$
For Inspection Work.	W_1 = { Maximum safe center load including stringers, track, etc.	$W_1 = \frac{C_1 b d^2}{l f}$		
	S_1 = { Maximum safe shear and crushing stress.		$S_1 = \frac{C_2 b d}{f}$	$S_1 = \frac{C_3 b c}{f}$
	f = { Actual factor of safety.	$f = \frac{C_1 b d^2}{W_1 l}$	$f = \frac{C_2 b d}{S_1}$	$f = \frac{C_3 b c}{S_1}$

USUAL VALUE OF f = FACTOR OF SAFETY.

	Tranverse and Shearing Stress.	End Crushing.
For Elastic Limit.........	e = from 3. to 4.	
" Impact...............	i = " 1.5 " 1.5	i=from 1.5 to 1.5
" Ordinary Defects.....	d = " 1.5 " 1.7	d= " 1.5 " 1.7
" Non-Continuity of Stringers.....		m= " 1. " 1.4
Continued Product........	$f = eid$ = " 6.75 " 10.2	$f = i\,d\,m$ = 2.25 3.75

CONSTANTS FOR USE IN ABOVE FORMULÆ.

TIMBER.	C_1 Quiescent breaking center load in lbs. b d and l=1″	C_2 * Shearing strength transverse to fibre, lbs p. sq. in.	C_3 Stress in lbs per sq. in. to produce indentations of .... .01 in	C_3 .1 in
American White Pine..................................	5400	2500	300	600
Yellow Pine, best....................................	6000	4300	500	1000
White Oak..	7200	4400	800	1600
Spruce...	5400	3250	350	700

*Stringers strong enough to withstand the tranverse stresses are usually amply safe against shearing stress.

The foregoing table of Constants is based on the data of Trautwine.

In planning new work, having obtained values for W and S by the methods explained below, the formulæ of the first four lines may be used with suitable values for f and C to determine the limiting dimensions for stringers.

In inspecting existing trestlework, we use the remaining formulæ to determine whether the actual loads and factors are sufficiently safe with a view to strengthening them if necessary.

The factor of safety f occurring in the foregoing formulæ really represents the continued product of several factors, introduced, *first*, to avoid straining the timber beyond the elastic limit; *second*, to allow for the impact of the moving load; and *third*, to allow for ordinary imperfections of timber, since the Constants are derived mainly from experiments on small specimens whose perfections are seldom realized in practice.

The elastic limit for wooden beams usually lies somewhere between $\frac{1}{3}$ and $\frac{1}{4}$ of the ultimate breaking strain. Reducing the constant to $\frac{1}{3}$ or $\frac{1}{4}$ of its tabular value to avoid stresses beyond this limit is the same as giving to f values of 3 and 4 respectively.

Impact.—A load suddenly applied is considered to have twice the destructive effect of a static load, and a heavy train coming swiftly onto a bridge to occupy a position intermediate between the two. Hence for short spans we may say that the motion increases the destructive effect 50 per cent, or what is the same thing reduces the constant by $\frac{1}{3}$ part, which is equivalent to assuming $f=\frac{3}{2}$.

Ordinary imperfections in timber are such as knots, crooked grain, improper seasoning, wind shakes and cracks, natural variations

in strength owing to different conditions of growth, &c. The authorities usually advise a reduction of the constant of at least $\frac{1}{3}$ to allow for loss of strength from these causes which would correspond to f taken equal as before to $\frac{3}{2}$; but as 10 is an almost universally accepted value for f being the continued product of these several component parts of f we may take as an allowance for ordinary defects of timber f varying from $\frac{3}{2}$ to $\frac{7}{4}$ which will give us the following result applicable alike to transverse and shearing strains:

For Elastic Limit	$e =$	from	3.	to	4.
" Impact	$i =$	"	1.5	"	1.5
" Ordinary Defects	$d =$	"	1.5	"	1.7
	$f = e \times i \times d =$	"	6.75	"	10.2

With exceptionally good timber d may be taken even lower than 1.5 and with very poor stuff must be even greater than 1.7. Some conception of the elements which combine to form the value of f is useful when f in an existing structure figures lower than we consider safe; thus if we find in a given trestle that f only figures 5.5 instead of 10 as we would wish to find it, if we can agree to the foregoing analysis of f, assuming the timber to be of good quality, we may reason as follows:

By slowing down all trains we make $i = 1$, and assuming $e = 3.5$ and $f = 5.5$ as already found, we then have from the equation $f = e\,i\,d$,

$$d = \frac{f}{e\,i} = \frac{5.5}{3.5} = 1.57.$$

This being a permissible value of d, we could still allow the trestle to be used until it could be properly strengthened, provided we slowed down all our trains.

A similar course of reasoning can be pursued with reference to the factor of safety against end crushing.

For impact we may take $i = 1.5$, and for ordinary defects of timber $d =$ from 1.5 to 1.7. We need, however, to consider the effect of deflections in a non-continuous stringer in raising the end and rendering the bearing imperfect and partial. With a 12-inch cap and a stringer deflection not exceeding 1-1200 of the span, an indentation of about 1-200 of an inch will occur at the edge before the end attains its bearing, aud the loads required to produce 1-100 of an inch indentation with continuous and non-continuous stringers respectively may be roughly assumed as in the proportion of 4 to 3. To allow, therefore, for this imperfection of end bearing we should for non-continuous stringers reduce the constant for 1-100 indentation to $\frac{3}{4}$ of its tabular value or take $f = \frac{4}{3} = 1.4$, nearly. Doubling the load produces ten times as much indentation, so that with an indentation of 1-10 of an inch the constant would not be materially reduced; hence in allowing for non-continuous stringers, denoting

the new component of f by m, we take m varying from 1 for continuous to 1.4 for non-continuous stringers and as before we have the following equation and table:

For Impact	$i =$		1.5		1.5
" Ordinary Defects	$d =$	from	1.5	to	1.7
" Non-continuity of Stringers	$m =$	"	1.0	"	1.4
	$f = i \times d \times m =$	"	2.25	"	3.75

The above factor of safety 3.75 seems small because the constant C_3 is for use with an indentation within the crushing limit of the material, while the factors for shear and transverse stresses are for use with constants taken at the point of rupture. With f = 3.75 and C_3 (for indentation .01 inch) = 300 pounds per square inch for white pine the safe stress = 300 ÷ 3.75 = 80 pounds.

Trautwine gives 800 pounds per square inch as the crushing pressure for white pine; and a stress of 80 pounds has a factor of safety of 10, so that the factors 2.25 to 3.75 with constants for an indentation of 1-100 of an inch really correspond to f varying from 6 to 10 with Trautwine's value of 800 pounds per square inch as the resistance to crushing. In this connection consult Trautwine.

As a rule the authorities preserve a discreet silence on this topic, so that it is with some hesitation that I advance my own views as to the proper values to assign to f and C_3. It is quite likely, however, that in the average trestle the deflection exceeds 1-1200 of the span, and that on the other hand, an indentation considerably greater than .01 inch would not materially injure the stringer ends, but as these facts tend to neutralize each other I presume the values suggested for f are not greatly in error.

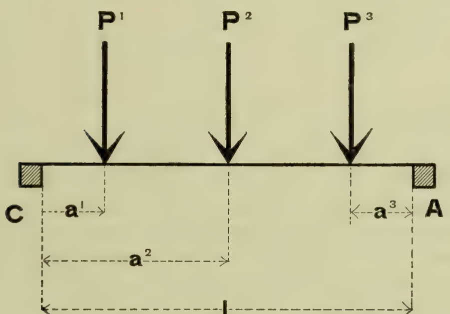
Transverse stress on the stringers and computation of W and S. I have already discussed the subject of the rolling load. 3,500 ℔s. per foot headed by 50,000 ℔s. of concentrated load, however, is at present advocated more particularly for dimensioning large and important structures of iron where strengthening is practically out of the question than for use with such structures as are here discussed. No such precautions are necessary or would seem to me good practice with pieces so easily replaced as wooden stringers; and yet we should not lose sight of the important fact that rolling loads are constantly growing heavier. With one-story trestles and 12-inch caps, fifteen feet is about the maximum clear span for the stringers; and at present, with but few exceptions, the stringer sustains its greatest stress from the drivers of a modern consolidation engine. 100,000 pounds upon a wheel base of 14 or 15 feet is not unknown, though as yet confined mainly to the more important lines of road, though recent specifications on a western road increase this to 30,000 pounds on each of four driving axles.

In the Railroad Gazette for December 10, 1886, occurs a diagram of loads for bridges and stringers by Mr. J. P. Snow, the loads varying from 10,000 pounds per lineal foot for 12 foot-spans to 6,000

pounds per foot for 20-foot spans. For a 15-foot clear span the value given is about 7,000 pounds per foot, indicating a center load of about 53,000 pounds.

In general it would seem therefore that not much less than from 45,000 to 50,000 pounds should be adopted as a center load for dimensioning track stringers in 16 foot trestles where heavy engines are used.

Fig. 4



Computation of W (See Fig. 4).—*W* being an assumed single center load which will produce at the center of the stringers a stress equal to the greatest which the given loads can produce, the nearer a load to the center of a stringer the greater its destructive effect, hence the maximum stress at the center will probably occur with the heaviest load at the center of the span and as many other loads on the stringers as possible. A few trials, however, will usually determine the position of the loads producing the maximum stress.

In general for any position of w^1 &c. on the stringer, $p^1 =$ a center load producing a corresponding stress at center $= (\frac{2}{l})\ a'\ w'$

And if $W =$ a center load equivalent in its effect at the center of the stringer to the combined effect of $p'\ p^2\ p^3$ &c.

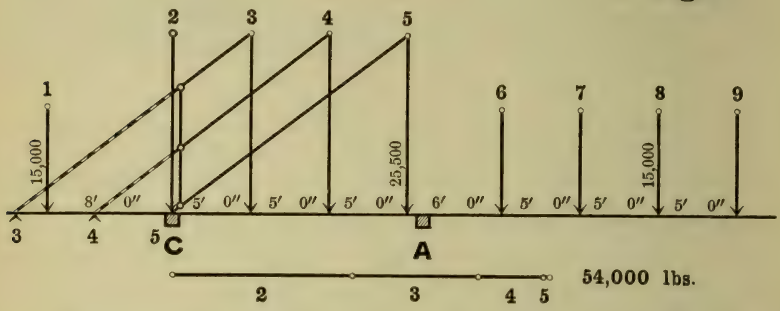
Then $W = p'\ p^2\ p^3$ &c. $= \frac{2}{l}\ (a'\ w' + a^2\ w^2 + a^3\ w^3$ &c.)

That is if each load is multiplied into its distance from the nearest bent, and the products are added, doubled, and divided by the clear span, the quotient is an equivalent load, which acting at the center of the stringer produces the same stresses at the center as the greatest which the given system of loads can produce; and if a stringer can safely sustain this stress, it will sustain any stress caused by any other position of the load system owing to its uniformity of cross section.

W as well as *S* may be computed by the methods of graphic

statics or by any of the methods laid down in the works on bridge building.

Fig. 5



Computation of S (See figure 5).—*S* is the greatest value of the shearing stress at any section of the stringers. This can be computed in the manner already explained when treating of the stress on the trestle bents, but a slightly different load position must be used. The maximum shear comes directly over the edge of the caps, and one of the heaviest loads should be placed at the edge of the cap with as many more of the heavier loads as can be brought upon the stringer, and the stresses are then obtained and summed up as in Figure 3. For end crushing the loads are advanced a little to the left till the heavy load is over end of stringer or center of cap as shown in Figure 5, the value of *S* being slightly greater for end crushing than for shearing stress.

Bank Bents.—Trestle work usually begins and ends in an embankment, and a common but not commendable foundation for the bank ends of the stringers is a series of four 6-foot mud sills laid longitudinally on the embankment, upon which rests a 12″×12″−8′ cap, which in turn supports the stringers, their ends abutting against a three inch plank set edgewise. An inexpensive and much more solid support, however, may be formed by driving under the stringers two 10 or 12 foot piles and drift-bolting a cap on top of them.

Bridge Ties.—The bridge ties are usually sawed 8 inches broad and 7 inches deep, and range from 9 to 14 feet in length, the ends of long ties being supported by jack-stringers as already described. They are usually boxed down one inch on to the stringers to resist lateral stresses, and spaced from 10 to 16 or more inches from center to center, close spacing being intended to diminish the shocks caused by a derailed truck. They should be laid with great care and so as to afford a full bearing to the rail in order that each tie may receive and transmit to the structure its own proper share of the load and no more. Spiking ties to the stringer is neither necessary nor advisable.

Guard-Rail.—The guard-rail is usually a 6x8 inch stick placed on each side at the outer extremity of the bridge ties. It serves to prevent the train from leaving the trestle in case of a derailment, but it also helps to stiffen and strengthen the structure and incidentally keeps the ties square with the rails and properly spaced, being boxed down onto the ties and then bolted to every third or fourth tie, some constructors using lag screws at intermediate ties. All trestles, however, should be provided with the ordinary iron guard-rail, and the addition of Mr. Latimer's re-railing device at each end together with the flaring of the wooden guard-rail into wings terminating in wooden posts is good practice. Three-inch planking, one foot broad, should extend along the trestle midway between the rails for convenience of trackmen and trainmen in crossing; and if the trestle is long, platforms should be built out on the caps at intervals of 200 feet or more for the reception of tubs or barrels where water can collect for use in case of fire.

Material.—The material used in construction of trestles varies greatly. Yellow pine at the east and northern pine at the west seems to be the rule for stringers. Oak stringers are deemed treacherous and subject to internal decay, but are sometimes used with a high factor of safety on the score of economy, and oak and other timber is in constant use for caps and piles; guard-rails and bridge ties are either of oak or of chestnut, pine also answering well for all these purposes where cheaper than oak.

Cost of Trestles.—When estimates of cost are made for the trestles of an entire line, they are often averaged at $30.00 per thousand feet B. M. of timber, but above certain sizes timber increases so rapidly in price that in individual structures detailed plans and estimates are necessary.

Ordinary low pile trestles will cost not far from $4.00 per lineal foot, but may run somewhat cheaper or dearer, depending on the price of material, plan adopted, &c. As an example from actual practice, in the construction of the I., D. & S. Railway in Indiana, 1879 to 1881, pile trestle averaged $456.00 and superstructure of wooden bridges $362.00 per mile. Much of the Indiana section of this railway (68 miles) is located in hilly country, while the 84 miles west of the Wabash river may be classed as prairie road, being in the so-called "Grand Prairie" of Illinois.

Quantities.—The materials used per mile in trestles averaged about as follows:

On the Illinois section 4,890 ft. B. M. of timber, 223 lin. ft. of piles, 316 pounds of wrought iron bolts and nuts, and 123 pounds of cast iron washers.

On the Indiana section 5,489 ft. B. M. of timber, comprising 2,333 ft. of oak at from $25.00 to $30.00 per thousand erected, and 3,156 feet of pine at from $13.00 to $16.00 per thousand; 354 lin. ft. of piles at 25 cts. per foot in position, 245 pounds of wrought iron

bolts and nuts at 5½ cts. per pound, this all being on a contract covering 49 miles of road.

An average of three one-story sill trestles of moderate heights gives 78 feet of timber, 3 pounds of bolts and 2¼ pounds of cast washers per lineal foot of trestle, and they required about 39 pounds of bolts and nuts and 28 pounds of washers for each thousand feet of timber.

Again a couple of two-story sill trestles of entirely different design, 32x34 feet high and 20 and 26 feet span respectively, at $30.00 per thousand for timber, cost about $6.00 per lineal foot and contained 40 pounds of bolts and 30 pounds of cast washers per thousand of timber.

In estimating iron work for trestles, we may take the cast washers at one pound each, estimating bolt head and nut at .454 pound for ¾-inch bolts and 1.923 pounds for 1¼-inch bolts, and estimating each lineal inch of bolts at .124 pound for ¾-inch bolts and .344 pound for 1¼-inch bolts. For drift-bolts, &c. $W = .218\, d^2\, l$. W = weight in pounds, and d = diameter, and l = length in inches.

The price of material varies in different places. On our Indiana section timber is very scarce, and we pay for oak bridge timber from $13.50 to $30.00 per thousand for pieces ranging from 20 to 50 feet long, prices varying with the length.

Piling in ordinary lengths from 10 to 12 inches diameter at smaller end, costs from 13½ to 15 cents per lineal foot. All of these prices are for material loaded on the cars. Bolts cost about 3 cents and cast washers 2 cents per pound.

The labor on any particular style of trestle is usually estimated in dollars per thousand of timber, and to estimate closely requires actual experience in construction.

Bell, in his work on carpentry published in 1875, for ordinary bridges and trestles for railways, estimates labor in the western states at about $11.00 or $12.00 per thousand of timber in the finished structure.

The labor on trestles will probably range from $7.00 to $14.00 per thousand, depending upon nature of plan, rates of wages, locality where erected, &c. Piling we may ordinarily estimate at 25 cents per lineal foot for piles driven in position, and in default of actual data allow in ordinary cases for the length of the pile below the surface about 12 feet in clayey soil of Indiana and on the Illinois prairies about 18 feet. The above price, however, only applies to heavy contracts. On our own road, not allowing for interest on cost of plant, the cost of driving piles on heavy jobs varies from 5 to 8 cents per foot of piles, but for odd jobs the price will largely depend upon the amount of work to be done and the facilities at command.

Kind of Trestle to be adopted.—Which class of trestle, pile or frame, is to be preferred in a given case, varies with circumstances. Pile trestle has a longitudinal stiffness, which a frame trestle has not,

and which in the latter type can be obtained only by longitudinal bracing. Much depends on the character of the foundation and height of trestle. For all cases when with the appliances at hand the soil permits of driving piles to a secure foundation, and leaves length enough above ground for necessary height, I should favor pile trestle work. Where the nature of the ground precludes the use of piles, frame trestle must be used, and that foundation adopted which in each case gives the best result for the least money.

Mud-sills are poor practice, though much better than the reprehensible custom of laying the sill in a trench and covering it up with earth, which has been practiced in the past to an incredible extent. Where the longest pile that can be secured, or can be driven with the appliances at hand, must be driven nearly flush with the natural surface before sufficient sustaining power is obtained, the best plan is probably to cut off and start a frame trestle on the piles as a foundation, one stick usually serving both as cap to the piles and sill to the frame. But I am in favor as far as possible of using long piles so driven as to afford sufficient sustaining power and yet projecting above the natural surface to such a height as shall permit of sawing them off, capping them, and placing stringers directly on the caps, and of using a frame trestle only where this plan of construction can not be carried out; for in the case of frame trestles when the expense of frame and foundations is considered, I think we shall usually have a dearer structure than if piles are carried up to their extreme height before passing to the frame type of trestle.

Specifications.—In contracting for material, specifications must be prepared; and the following printed form in use on one of our leading western roads is handy and shows the usual requirements, the blanks being filled up and dimensions of pieces, &c., written in as occasion requires:

ORDER NO........ BILL OF MATERIAL. BRIDGE NO........

Specification for Timber.—All timber shall be first-class, of the best quality of............and shall have been cut from living timber; it shall be free from rotten or loose knots, and without sap angles greater than............inch, and shall be free from sun cracks and wind shakes, and must be evenly sawed.

Specifications for Iron.—All wrought iron shall be of the best quality of fibrous iron, capable of resisting, without rupture, a strain of 50.000 pounds per square inch, and a strain of 25,000 pounds per square inch without permanent set. All rods and bars shall be made without weld, and when designated shall have upset ends. The ends shall be cut with threads according to............standard. All castings to be made from the best quality of iron for the work designated, and strictly in accordance with plans furnished.

I, ..., of.........County, State of........, hereby agree to furnish............., of.........County, State of......., the bill of material as given below, and according to specifications

accompanying, at the prices marked for each item. All material shall be subject to the inspection of............, and all rejected material shall be at our loss, ...agreeing to replace all the material as specified below, on cars at.........on the line of the........ Railroad, by the......day of........., 188 . We hereby agree to pay to said............as damages, the sum of.....cents per...... per day, for each day, except Sundays, so delayed at the option of said............

NUMBER OF PIECES.	NAME OF PIECE.	SIZE.	LENGTH.	FEET OR POUNDS.	PRICE.	TOTAL.	REMARKS.

The Cincinnati Southern Ry. specifications required bridge timber to be "free from wind shakes, large knots, decayed wood, sap, or any defect that will impair its strength and durability. No sap angle will be allowed. * * * All framing must be done in a thorough and workmanlike manner."

Sap-wood finds but little favor with builders, as its life is only about one-fifth that of sound timber, and it should as far as practicable be ruled out in the specifications, though it will be found difficult to do this absolutely in practice.

Yates' standard specifications provide as follows: Bridge timber to be of white pine and white oak, sound, free from want, loose knots and other imperfections, and sawed straight and square, the several pieces to be accurately framed and put together with all necessary bolts and washers. They also provide that piles are to be "of round timber, straight, free from rot, large knots and other imperfections, barked, accurately pointed, and banded at the head while driven to prevent splitting, and when required, to be shod with a cast iron shoe. To be measured after cutting off the tops, and paid for by the lineal foot, price to include cutting off, pointing and finishing smooth and square ready for caps."

Barking piles adds but little to the cost of work, but greatly increases their durability.

Preservation of Piles.—Piles are sometimes treated with some preservative solution before being used—creosote for example—and the time will come when this will be the rule rather than the exception. When properly treated the life is increased several fold,

while with the proper facilities at hand the first cost of material is only increased about from 40 to 60 per cent. With piles costing 25 cts. per foot driven, and lasting not more than 8 or 9 years, it would certainly seem economy to expend a few cents more per foot, since their life is thereby greatly prolonged.

Piles usually fail either by being destroyed by boring worms, which work under water and completely honeycomb the pile, or else they rot prematurely near the water line or ground line. After a thorough treatment by some chemical process, perhaps the next best and certainly a very judicious thing to do is that recommended in the Report of the Ohio Railway Commission for 1884, being an application of hot tar at the ground line where the pile first gives out. It is quite probable that a similar and liberal use of whitewash or quicklime would be a good investment, as very good results have in this way been obtained with railway cross ties.

Dimensions for Standard Trestle.—The following dimensions are submitted for a one-story pile trestle suitable for a western road of ordinary traffic.

Bents of 4 piles each. Piles not less than 8″ diameter at smaller end, driven to a 2″ penetration under a 2,000 pound ram falling 20 feet or an equivalent thereto; sawed square at top. To these a 14″×14″−14′ cap is secured by 1¼″ drift bolts driven 8″ into each pile. Two sway braces of 3″×12″ plank bolted to the cap and to each pile. Bents spaced 15′ from center to center. Track carried by 6 stringers, size 6″×16″×30′, spaced by iron spools or blocks. Each set of stringers secured to the cap by a 1¼″ drift bolt or by wooden blocks. Stringer bolts ¾″ diameter with cast washers 3″ diameter. Bridge ties 7″×8″×9′ spaced 12″ center to center and boxed down 1″ on stringers. Guard-rail 7″ × 8″, boxed down 1″ on ties and bolted to every third tie with lag screws at intermediate ties. Iron guard-rail on entire length of trestle, with Latimer re-railing device at each end with wooden guard-rails flared and terminating in guard posts projecting about 4 feet above ground.

Inspection and Records.—Bridges and trestles are usually numbered in consecutive order, and some permanent record kept of dimensions, repairs, &c. I would suggest the following system of records as being in some respects an improvement on present practice.

Number all bridges, trestles, culverts, &c., consecutively in one direction, also number each pier or bent and span of trestle on bridge of each structure in the same direction. Number stringers and similar pieces from right to left, and stories of trestles from the ground upward. In this way every piece in a trestle or bridge can be readily designated; for example "Trestle 38, pile 3, bent 2," on a road numbering its bridges from east to west would mean—Third pile from the north in the second bent from the east. Actual numbers should be placed on each structure and on each bent or pier. A page in the Bridge-book should be devoted to each structure, on which

should appear either a plan of the same or a reference to the standard plan to which it is built, date of building, cost, &c.; and here from time to time should be made a minute record of all repairs, specifying by the above system of enumeration just what pieces are replaced with the date when, cost of replacing same, and any data affecting the condition of the structure, especially records of penetration of piles as driven.

In inspecting trestle work we should ascertain when the structure was built and how much has since been expended for repairs. Its first cost if not known can be estimated and we may reason that ordinary repairs should at least average one-eighth of the first cost per annum. Any less expenditure implies deterioration and should make us doubt the present safety of the structure unless it be a comparatively new one.

Coming now to the field work, we assume the structure sound and determine whether it is safe under existing traffic, and if so, then ascertain whether the various pieces of timber are sound or need replacing. The stringers should receive very close attention; so also the bridge ties. A stick may often present a fair appearance to the eye and yet be rotten to the core. An expert by sounding timber with a hammer can readily tell from the dead sound where anything is wrong, and close inspection will usually reveal some suspicious looking place where boring or probing with a suitable sharp-pointed instrument will disclose the rottenness if there be any. Excessive boring should be avoided as it tends to weaken the structure. Remembering that where water tends to collect there rot is most likely to set in, we look carefully to the ends of stringers, especially where corbels are used, also around packing blocks and keys, and caps, and where joints or mortises occur in framed work, &c.

In pile trestles the piles should be rigidly scrutinized at the water or ground line, and tested with a pick or other pointed instrument, and also at any knots or suspicious looking places, and they should be sounded with an ax or maul.

With sill and pile trestles not built in water, the earth should be removed with a shovel to test the portion of piling below the surface and to investigate the condition of sills and mud-sills which may have become covered up by the soil washed down by storms. Bolts and nuts should also receive their due share of attention, and in fact every portion of the structure should be carefully inspected, for in railroad work the safety of valuable property and of human life even may turn upon the failure of a rotten stringer or a rusty bolt, and nowhere is the saying a truer one that "Eternal vigilance is the price of safety."

DISCUSSION.

Mr. Talbot.—I would like to speak of two points. In regard to the effect of the last blow on a pile, in the work I am familiar with the specifications required the last blow from a 2,000 pound hammer

falling 20 feet to drive the pile not more than ¼ of an inch. For railroad work such a limit need not always be used. When a pile is 8 or 10 feet in the ground and there is no danger of the pile washing out, a settling of 3 or 4 inches at the last blow may not be too much, for the small amount of settling from the traffic may be remedied by shimming at the time of periodical repairs. The stringers used in the pile bridges of the A., T. & S. F. R. R. are cut down 2 inches on the under side where they rest on the cap—for the purpose of keeping the bridge from sliding. They frequently fail by cracking and splitting back from the interior angle of this rabbet,—the impact of the moving loads passing over them being too great for the resistance of the wood to longitudinal shearing. The construction should be condemned.

Mr. Hill.—I am certainly opposed to that construction, because of cracks and because of collections of water. I like the stringers to rest their full thickness on the caps, the joints of the stringers to be broken on alternate caps.

Mr. Baker.—The paper is undoubtedly a good one, but I desire to take exception to what was said about formulæ for bearing power of piles, even though the author has good precedent and reputable practice on his side. However, it is too late to discuss the matter now.

EXECUTIVE SECRETARY'S REPORT.

To the President and Members of this Society:

The following is the report of the Executive Secretary for the past year:

RECEIPTS.

Advertisements	$114 60
Reports	70
From Treasurer	93 10
Total	208 40

DISBURSEMENTS.

Printing report for 1886	157 30
2 Photo-engravings for report	10 25
Returning cuts to advertisers	85
Circulars, certificates and other printing	13 75
Postage	16 82
Express, etc., on reports of other societies	7 18
Stationery	2 25
Total	208 40

The Engineering Era, now defunct, failed to pay its advertising bill. 1,000 copies of the Report were printed. Exchange copies were sent to the State Societies in Michigan, Ohio, Indiana, Missouri and Nebraska. The Missouri and the Michigan Reports for 1885, and those of Ohio and Indiana for 1886 have been received and distributed. Extra copies of these and of our Report as well as of several miscellaneous publications are on hand for distribution.

A detailed report of the expenditures has been made to the Executive Board, which may be seen by any interested in it.

A. N. Talbot, Executive Secretary.

TREASURER'S REPORT.

To the President and Members of this Society:

The following is the report of the Treasurer to the close of the 2nd annual meeting, Jan. 28, 1887:

RECEIPTS.

Membership fees, 45 @ $3	$135 00
Assessments for 1887—11 old members @ $3.00	33 00
8 new members @ $2.00	16 00
A. H. Bell, card in 1st Report	3 00
	$187 00

DISBURSEMENTS.

I. O. Baker, expenses of 1st annual meeting	$ 13 20
Executive Secretary, expenses of printing report, &c	65 00
" " " " "	28 10
Treasurer, expenses of printing blanks, &c	3 00
Balance in treasury	77 70
	$187 00

Geo. P. Ela, Treasurer.

REPORT OF EXECUTIVE BOARD.

To the President and Members of this Society:

Your Executive Board respectfully submit the following report and recommendations:

We have examined the vouchers of the Treasurer and found his accounts correct.

In order to meet the probable expense of publishing our Report for the present year, we have made an assessment of $3.00 each upon the old members and and $2.00 each upon members who join during the present year.

We recommend that the Socicty devote the sum of $60.00 for the remuneration of the Executive Secretary for the present year.

We recommend that the standing committee on Sanitary Engineering and Water Supply be changed, and hereafter be known as that of Municipal Engineering.

Your Executive Board have voted that all papers presented to the Society at the regular sessions be handed to the Recording Secretary at once, which shall not be printed in full previous to appearing in the annual report of the Society.

C. G. Elliott,
D. L. Braucher,
I. O. Baker,
A. H. Bell,
A. N. Talbot,
Executive Board.

REPORT OF THE LEGISLATIVE AND JUDICIARY COMMITTEE.

To the President and Members of this Society:

The duties of your committee we believe to be the collation of decisions of the courts of record in this and other states, and to make suggestions for changes in the laws of this state that in our judgment will be of benefit to the engineer and surveyor.

The result of the labors of your committee in regard to the collection of opinions of courts is of no importance, there being no decisions so far as your committee could ascertain in this state touching subjects of interest to members of our association. We would

like to suggest here, however, that as court decisions are scarce affecting the interpretation of the laws and actions of members of our profession that it should be an object of the members of the association to seek to know the laws of the state in all points so that by careful judgment and application of the evidence in the matter be able to tell what the decisions in such a case should be. The differences in the decisions of courts are such that court decisions cannot be relied upon to any great extent, and although lawyers seek with avidity to find court decisions in support of their cases yet they oftener than any one else regard those decisions with indifference. A prominent lawyer of Springfield some years ago who was associated at the bar with the early practitioners in this state—Lincoln, Douglas and Logan—said that in those early days lawyers sought to make decisions and not to seek them. So the members of the engineering profession should so study the law of our state as it exists that they may discern what should be the decision in cases affecting their profession and actions, and so help in the formation of proper decisions.

In regard to recommendations for changes in our laws your committee feels that it is not best for your committee to formulate any laws and urge their passage, but to leave that with the association or to a committee authorized to formulate and present the same.

Your committee would heartily recommend that the law be amended to require every civil engineer, mining engineer and surveyor in the state to obtain a license to practice his profession in this state, the issuing of said certificate of license to be upon ability, knowledge and skill of the person seeking it. We believe this to be the most necessary thing needed at the present in behalf of our profession. It will put the profession of engineering and surveying along with the other professions of medicine, law and pharmacy, and require of the engineer and surveyor that knowledge and preparation for his business that his responsibility will justify.

Another change recommended is that of the law in regard to the duties of the mining inspector. The law at present makes it his duty to see that owners and operators of mines shall annually file in the recorder's office of the county in which the mine is situated a survey of the mine. In many cases this duty is neglected, and we would suggest that the action of the mining inspector in this regard be subject annually to the inspection of a committee of the County Board, who shall report that the proper plats are annually filed or institute proceedings against the mining inspectors for failure in performance of duty.

Another change recommended is that in the law in regard to the payment of the county surveyor for the recording of plats now required by law to be filed in his office. It seems to your committee that if these records are worthy of record for the good of the public that the additional work required so to do should be paid for by the public who are benefited thereby.

Another change recommended by your committee is that of the law in regard to permanently fixing and continuing monuments of survey. Some way of permanently fixing and keeping established corners, especially government corners, to be done and paid for by the public, should be established, and not depend on the indifference of individuals to maintain these monuments. This perhaps could best be made one of the duties of the county surveyor, requiring him to see that all government corners in his county are kept perfectly and have a record kept in his office of the location of monuments, what they are composed of, and when placed there or removed. This would prove of invaluable service to all surveyors and to owners of real estate. The same work could be performed in cities by the city engineer who should have the general supervision of all work of that kind in the city.

We do not urge the formulation and passage of all these laws at the present session of the legislature, but at as early a day as possible.

S. A. Bullard, Chairman.

REPORT OF COMMITTEE ON LAND DRAINAGE AND PUBLIC HIGHWAYS.

Mr. President and Members of this Society:

Drainage.—The State of Illinois compares favorably with other other states in the energy and push which she shows in her enterprises connected with land drainage. The past year has been one of activity in this regard. It seems impossible for your committee to obtain accurate statistics of the amount of drainage which has been done in the several counties during the past year, though quite a correct general idea of the progress made has been formed from reports from various sources.

The formation of drainage districts under our present law is now common, and seems to open avenues for the successful drainage of large tracts of land. In Iroquois, Champaign and McLean Counties there have been about 110 miles of large ditches projected and under construction during the past year. Other counties have work of this kind on hand but we have no definite information concerning it.

The large amount of tile drainage that has been done in the same time can be judged of from the fact that the product of about 700 tile factories has been used. There are many localities in which very little drainage has been done at all, some of which have just begun during the past year, so that we can safely say that there has been no falling off in the drainage business during the past year.

Of all of the tile drainage that is done annually in this state it is probable that not more than five per cent. of it receives any attention from an engineer, so that while engineers may not be employed on this work, there is ample room for practice, if those having land to drain can be convinced that there will be a profit in their favor if they employ one.

There is an important problem for the profession to solve in connection with the work of land drainage. It is with reference to the formulæ to be used for obtaining the discharge from drain pipes and channels and their application to various cases. The coefficient of flow for various drain pipes has never been determined. Neither has the relation of the size and length of drains to the area to be drained been determined; or in other words what should be the size of the outlet with reference to its nearness to the area for which that outlet is made. For the determination of these relations, a series of experiments and observations upon drainage work in operation, is necessary. Engineers are now using coefficients of flow which have been determined for other purposes. There is abundant room for such research as will bring the mathematical department of drainage engineering upon the same reliable basis as other hydraulic work.

Public Roads.—The improvement of public roads progresses at a snail's pace. Private land drainage is far outstripping it, yet the two in many localities are so closely connected that land drainage must precede all radical road improvement. As a rule, road drainage is endorsed and practiced wherever the conditions are favorable and funds are available. At a convention of Highway Commissioners held at Springfield last April, mvch excellent advice concerning the construction and management of roads was given, but all effort to systematize road management and to lift it out of the disconnected and expensive method now in vogue was signally opposed by the majority of those in attendance.

The sentiment for better roads is becoming stronger each year, and were the material near at hand, there would soon be a general movement in the direction of permanent road surfaces. This we find is the case where gravel is available. With the aid of drainage and embankment, we can make a good foundation for some durable surface material, which is necessary for a good road at all seasons of the year. Where gravel is not accessible, it occurs to your committee that crushed stone will be better for the purpose, especially when the material must be shipped by rail. It will be more valuable in proportion to the tonnage, besides making a better surface for the road. At all events, the permanent-road-surface question is the one we now have to meet and the more expeditiously it is solved the better it will be for our state.

C. G. Elliott, Chairman.

REPORT OF GENERAL COMMITTEE OF ENGINEERING.

To the President and Members of this Society:

A Closer Union of Engineering Societies.—The question of a closer union of Engineering Societies, which has of late formed a subject of discussion before the American Society of Civil Engineers and the Associated Engineering Societies, is one in which all engineers should take a lively interest. A considerable difference of opinion exists as to the degree of closeness of union which should exist between such societies in this country. Some prefer to have the society in which they are interested entirely independent of all other societies; others would like to see all engineering societies of the country which are of good standing, made branches of some parent society. I think neither of these extreme conditions are desirable at present.

The proposition to make the American Society of Civil Engineers the parent society, and the local societies offsprings, is beset with many difficulties, and a radical change in that direction, in the near future, is probably neither desirable or possible. On the other hand, the present complete isolation of some societies of good standing greatly impairs and confines their usefulness. The proposition to have a joint publication, if adopted, would be a forward stride for the benefit of all engineers.

The success of the Journal of the Association of Engineering Societies augurs favorably for a more general publication. The greatest opposition to such an associated publication will doubtless come from those who think their society the equal or superior of others and think that in a measure they will lose their identity by such a movement. This latter idea is a mistaken one. The man who identifies himself with work in which others are interested and who mingles with his fellow men may be as independent as the hermit, while exercising a vastly greater influence for good. So it may be with any societies if they combine in their most important work, that of improving the profession. This work is best carried on through the publications. A joint publication could be so conducted that each society would be fairly represented by having its proceedings and its best papers published, the papers being credited to the proper society.

Under the present system there are many societies which occasionally publish a journal; these journals often contain much that is

of interest to the profession at large, but their circulation is very limited, and but few engineers are so fortunate as to obtain all such publications without a very considerable expense, if he is able to obtain them at all. The advantages of a joint publication would be to give to each member of every society the best papers and the proceedings of all the societies associated, and at a small cost; to those who now receive all publications of the different societies, if there are any such, the expense would be materially decreased and the matter put in a much more compact form; the papers in such a publication would doubtless attain a higher standard than those of any one journal at present, as writers would consider the greater circulation to be given to their work and would also feel a pride in having their society well represented in comparison with other societies; and finally such a journal would soon reach a high position among engineering publications of the world; in fact it would soon be the leading engineering publication of this country, and of such demand that it would become largely self-supporting. If then the question of an associated publication with other representative societies of the United States should come before this association it is hoped that we will not "hide our light under a bushel" but unite in establishing a light which shall shine for the engineering profession throughout the world.

National Public Works.—The council of Engineering Societies on Public Works, after an enthusiastic beginning which promised much in bringing about a change in the conduct of Public Works, seems to have become so inactive as to create the impression that it is dead; possibly it may only be taking a rest preparatory to some hard work.

That the present system of conducting National Public Works is faulty in many respects is generally admitted; but has any better system so far been suggested? Any change which would throw open the field to all engineers irrespective of education or qualification for that class of work would be still more faulty, as the result would almost inevitably be that men who call themselves engineers but are in reality politicians would secure the direction of such works; in such case the works would certainly suffer by the change. It is to be hoped that if the above mentioned council resume work they will look to the adoption of a plan which will open the way for students from all engineering schools of a high standard, and that will at the same time keep the matter out of the field of politics.

We will briefly give the outlines of a system which it would seem fulfills as nearly as possible such conditions. Let a government corps of engineers be organized from army and civil engineers who have had an extensive experience in such works, and who are competent and faithful engineers; also, let the corps be partly composed of civil engineers of recognized ability; all members to remain permanently in the corps. The corps to be divided into grades, and members at the beginning to be graded according to experience and

ability. Each grade to have a fixed salary. The corps to be recruited from a government school, which gives one or more years of special training to a limited number of graduate engineers from accredited engineering schools and colleges of the country, or to other engineers who may rank high in an examination for entrance. The members of the corps to hold office so long as competent and faithful. Promotion to a grade to be made by competitive examination from the next lower grade, preference being given to senior members in the grade.

Works of Improvement of Mississippi River.—The failure of the last congress to make any appropriation for the salaries and traveling expenses of the Mississippi River Commission, while making appropriations for improvement according to plans of the Commission, has called forth some just criticism of that congress. At present it would appear that similiar tactics are to be pursued by this congress. It is conjectured that congress intends to freeze out the Commission, and place the work in the hands of army engineers. This might be no detriment to the work, but such a method of procedure would be unjust to the Commission.

The Commission, as might have been expected, have been severely criticized for things they have done and for things they have not done. Some claim that their work has been a total failure, that their plans are foolish, &c. They have been stigmatized as "parlor engineers," as "men who know only enough of hydraulics to know that water runs down hill," &c. The motive of many of these critics is easily seen. One has a patent dike he wants used and the Commission do not favor it; another wants to get a contract to improve the entire river; another wants to work a scheme through congress by which he can do a very small amount of work with a large amount of money, &c. But probably some of these critics are not so selfish in their criticisms, but fondly believe they have a plan or theory that is original and would be effective. Often these plans are senseless and theories second-hand. Most of these critics assume an extensive knowledge of hydraulics, some claiming a practical knowledge derived from years of observation. Almost invariably these writers show a great ignorance of the simplest laws of river hydraulics, and the practical observer has had no system of observation that would give more than a very superficial knowledge.

On the other hand, the Commission have some enthusiastic friends, who claim an unqualified success; while other friends, more conservative, side with some members of the Commission in saying that the work is still in the experimental stage. There is still another class who believe a permanent improvement at reasonable cost to be an impossibility by any method.

Recent surveys of the bank line and examinations of the works of improvement on both Lake Providence and Plumb Point reaches have been made by U. S. Assistant Engineer J. A. Ockerson by direction of the Secretary of the Commission. From these surveys

and examinations, in connection with previous surveys, maps of these reaches have been recently compiled, showing the bank line of the reaches for several successive years and showing all the works that have been constructed and their present condition. These maps give valuable data for a study and judgment of the value of the work done.

We will very briefly notice the condition of these reaches. An examination of the map of the Plumb Point reach shows that most of the dikes and revetments are still in place. The shore line at a 20 foot stage follows closely the outer portion of much of the work. Perhaps the most difficult piece of work on the reach is that of closing Bullerton Chute and protecting the bank of Bullerton Towhead by revetment; this has been completely successful, the works remaining in almost as good condition as when first completed. Some caving of banks has occurred in the bends of this reach, which in some places has been stopped by revetting. Ashport Bend (above most of the works) has caved 800 feet since 1879. Craighead Point below all the works has caved approximately 1,500 feet since 1879. On the part of the reach to which most of the work has been confined, the greatest caving has occurred in Fletcher's Bend; this caving amounted to 1,200 feet from 1879 to November, 1886. The caving on the upper and lower parts of the bend was stopped in 1884 by revetment. The bend between the two portions of revetment, however, continued to cave, and has caved behind and destroyed about one-third of the lower piece of revetment; this caving amounted to 400 feet from '84 to time of recent survey. All other revetment has remained in place and effectually stopped caving except a short piece near the lower end of the works known as the Craighead revetment. Caving of lesser extent has occurred at other places along the reach which are unprotected. So much for the works; now the important question is, what has been the effect on the channel? Soundings show that a good channel has been maintained during low water, and what was once considered to be one of the worst reaches for navigation at low water now gives no trouble to steamboatmen. Judging from present results and condition of works on this reach the enthusiastic friends of the improvement have good ground for their opinions. The works here *have* been a great success up to this time. Almost every pile driven and every piece of matress sunk seems to have had a good effect. The conservative friends, however, will ask, how long will these results last? Time alone can tell with certainty.

A first glance at the map of the Lake Provideuce reach will have a tendency to moderate the enthusiasm of enthusiastic friends. While in some places the works are in good condition,in many places they are badly broken and in other places almost entirely gone. Giving a hurried glance at the works in detail, we find in Louisiana Bend at head of the works a caving of 3,000 feet since 1881. In '84 and '85 the bend was revetted, and has caved but little since. The

revetment has, however, mostly slid down out of sight so that its actual condition can only be conjectured; just below this revetment a caving of 640 feet has occurred since 1884. Below this bend and on the opposite side of the river (left bank) was put in an extensive system of dikes and some revetment, known as the Duncansby system. This system has entirely washed away, except short pieces of the shore end of some cross dikes and some fragments of revetment of a small towhead. The bank just above this system has caved 1.500 feet since 1881.

It has been suggested that the caving in Louisiana Bend has caused this destruction, and with good show of reason, as the great amount of caving there tended to throw the current with its full force towards the opposite shore and against these works. Below this and on the left bank we find the Mayersville system in a badly damaged condition. The main dike at head of Mayersville Island is gone, and about two-thirds of the revetment of the bank of the island with a large part of the upper end of the island itself has washed away. The Cottonwood dikes opposite the head of this island are in good condition. It has been suggested, and seems quite probable, that the effect of these dikes was to throw the force of the current against the Mayersville system of revetment and aid in its destruction.

Of the remaining works the Baleshed and Stock Island systems are in good condition, while the small system called Elton dikes are washed away. Immediately below the Elton system the bank has caved 890 feet since 1881. About five miles below the lower works (the Stock Island system) there has been a caving of 2,020 feet since 1884. Although the work of this reach has been so much damaged it has made a vast improvement in the channel, low water navigation being easy where it was once extremely dangerous.

The question naturally suggests itself, why have these works not stood as well as those of the Plumb Point reach? Is it because of inferior work in planning or in construction, or, poorer management, or in more difficult conditions? Probably the latter is the principal cause. The banks on this reach seem to have less power to withstand the force of the running water, so the works would have to be stronger and more extensive to keep this reach in equally as good condition as the Plumb Point reach.

After this brief examination of the two reaches on which so much work has been done, we are led to believe that the conservative friends stand in the only rational position regarding the improvement of this great water-way—the Mississippi river. As a whole the work has *not* been the failure that its enemies claim, neither has it been the unqualified success which some have claimed, but there has been enough success to warrant a continuance of the work on a moderate scale. Mistakes have been made and methods modified, more mistakes will doubtless be made and further modifications of plans take place, before the best method becomes known of battling against the giant forces of the river. At present congress seems to be in

league with these forces and by irregular and insufficient appropriations and by injurious restrictions is perhaps doing as much to destroy improvements as the waters themselves. C. W. CLARK.

REPORT OF COMMITTEE ON INSTRUMENTS, BLANKS, AND RECORDS.

To the President and Members of this Society:

Your Committee on Instruments, Blanks and Records beg leave to make the following report. Owing to circumstances entirely unforeseen the exhibit of instruments has not been as large as was expected. We are glad to notice, however, the exhibition by Messrs. Heer & Seelig, of Chicago, of an Engineer's Transit and Y Level of improved make. The transit particularly shows remarkable accuracy of graduation, and both instruments show excellent workmanship. They also exhibit leveling rods, steel tapes, &c., well adapted to their various uses. Your committee would advise that the engineers and surveyors of the state give this firm a trial, both for new instruments and repairs before patronizing eastern firms, thereby saving much valuable time and expense.

We would also call your attention to an improved chain handle exhibited by Geo. W. Dickinson, of Charleston, Ill., containing a level and an arrangement for holding the pin perpendicular at each end of the chain while the measurement is being made. This device seems to contain considerable merit and is worthy of trial by all surveyors who aim at great accuracy of measurement in their surveys.

Among the late publications which should be in the library of every land surveyor we notice *A Manual of Land Surveying*, by F. Hodgman, of Climax, Michigan, which admirably supplies a long-felt want. Mr. Hodgman also exhibits a blank book for field use which has some valuable features.

In view of the great variety of work and greater accuracy required of surveyors, your committee would recommend the exclusive use of the transit, of which the engineers and surveyor's is probably the best for running lines, and the steel tape for taking measurements.

For the farm drainage engineer it would seem that something better in the way of a self-reading rod could be devised than has yet been seen by your committee. Also a Y level carrying a small needle, by which ditches could be located approximately for mapping while going over the ground taking the levels.

The attention of your committee has not been called to any

thing new or novel in the way of blanks or records during the past year. Though many deficiencies exist and the preservation of records is not what could be desired, owing to the want of a proper system, still those wants have not assumed such shape that your committee have any recommendations to make.

We would notice, however, the use of the "continuous profile book" in the record of the profiles of public ditches as a very great improvement over the ordinary roll of profile paper and would suggest that this use of the continuous profile book might profitably be increased.

D. J. STANFORD, }
GEO. M. CLARK, } Committee.

REPORT OF COMMITTEE ON MINING ENGINEERING.

To the President and Members of this Society:

Your Committee on Mining Engineering respectfully report that, in the absence of any precedent, it has been a question of some difficulty just what would be expected this year and how far it would be desirable to undertake any broad investigation before some definite expression had been obtained of the sentiment of the mining engineers of the state. We were appointed, as we understand, with a distinct understanding that the mine engineers and mine surveyors were not only welcome to our fold as active members, but that the civil engineers of all grades and specialties were desirous of getting into the society every earnest and competent mining engineer (using that term in its very broad sense). We knew that we could assure all such of a cordial reception and a full opportunity to participate in the deliberations of this body. For ourselves, we have had no hesitation in accepting this as the attitude of the members, and everything which we have done has been governed by that understanding. This meeting has convened and we think we can assert that something has been accomplished in the direction of our efforts. It is not what we have hoped, nor is it to us in any great degree satisfactory. We have individually, and as a committee, given every mining engineer, mine surveyor, metallurgical engineer and chemist of works, whose name and address could be obtained, a full opportunity to express himself freely, and they have all been invited to join the society. We regret very much the apparent lack of reciprocation, as shown by the small attendance of such persons this year, but we feel that our work has not been as valueless as its practical evidence to you might make it seem. We have at least accomplished this: The mining men now know your desire to co-operate with them, and it will be their loss and their fault if they do not respond in the same spirit. Another year they may be induced to come in

greater numbers, having seen the zeal and industry displayed at our two successful meetings. At any rate, they will be without excuse if they do not.

Aside from our efforts as indicated, we have also endeavored to learn if there be any cause but that of indifference, which has kept such persons away. We find that the date of our annual meeting is not just the most suitable for those engaged in mining, and that many are unable to attend who have manifested a desire to do so. Still, we do not think we can recommend a provision for an extra session until the mining members come forward and request it.

Some few persons appear to prefer an independent association for the mining men, and, of course, it rests wholly with those most directly interested to decide whether they will join us. But there are some very important questions concerning legislation in the near future, and topics bearing upon practice and the general routine in which all classes of engineers are equally interested. Upon these matters, and for the further purpose of mutual counsel and interchange of experience, there is no doubt that we can do each other good, and it seems worth while to continue the efforts for amalgamation until they have borne more abundant fruit. Certain papers upon mining topics, which were promised for this meeting, have not been received, but we trust that they may be published in the proceedings as regularly authorized contributions. We have felt great hesitancy in attacking the subject of the year's progress in mining engineering. The almost entire absence of serious accidents, the generally good character of the ventilation, the adequate provision apparently for safe and rapid egress from the mines, and many other safeguards which our efficient mining law and excellent system of inspection have secured, all are causes for gratulation. The fact that the Governor, upon the advice of the Bureau of Labor Statistics and the State Examiners, has recently reappointed all the mine inspectors, is a fitting tribute to their zeal and to the high character of their work.

The subjects of coal, oil and gas and their location within our borders are the dominant questions today in mining circles. There seems good reason to believe that we have hitherto unsuspected resources of this nature and the past year has been rather prolific in results, considering the indifference and ill-advised methods of research which have often prevailed.

In conclusion, we would respectfully advise that some action be taken by the Society, looking towards the assignment of a special day for the presentation of mining topics at the next annual meeting, and we ask each member of the organization to use his influence to persuade as many as possible of his mining friends to attend the meeting and join us, besides giving counsel and assistance by contributing to the transactions.

THEO. B. COMSTOCK, Chairman. } Committee.
RICHARD GRAY, }

REPORT OF COMMITTEE ON SANITARY ENGINEERING AND WATER SUPPLY.

To the President and Members of this Society:

In a report of this kind, a general review of the whole subject of Sanitary Engineering and Water Supply would be either too long or too fragmentary to be of value; and while in some places I have given generalities, it has been my main plan to give details of the parts I touched upon, leaving the remaining topics for other reports.

Engineering Supervision of Water-Works Construction.—Within the past two or three years the construction of water-works in Illinois towns has been unusually active, so that now most towns of 8,000 people and upwards have complete water-works, while many lesser towns have a partial system to insure fire protection. Part of these have been built by private companies and part are owned by the cities. Too often advertisements are made for bids on specifications copied from those of other towns having wholly different requirements and surroundings; plans are accepted by the board without any relatively thorough investigation by a competent engineer; and the works are constructed without proper supervision. True economy would always require proper engineering service in both design and construction. The practice of letting the contractor furnish the only engineering supervision should never be allowed. Contractors are human, and even when they are thoroughly upright, they may be densely ignorant of the requirements of the particular instance. Money expended by the town for a consulting and supervising engineer is well invested; and people must relinquish the idea that engineering advice can be obtained from trustworthy practitioners without proper compensation. The city engineer may not be fitted by experience or study to design the system of water-works. In such cases specialists should be employed.

Pressure Required.—The fire service in the business part of small towns, the pressure at each hydrant used must never be less than 40 pounds. Dividing this pressure by .434 we get 92 feet as the corresponding head. From a series of experiments reported to the American Society of Civil Engineers, I find that in still air the height of the average jet from 200 feet of $2\frac{1}{2}$-inch hose through a 1-inch nozzle equals 7-10 of the head at hydrant. This is a simplification of the complex formula given and is practically correct. A pressure of 40 pounds at the hydrant then would throw a stream 64 feet high. The usual wind at a fire will reduce this height materially, so that

the specification test should be considerably higher than the highest building. The pressure at the hydrant, however, will be much smaller than at the inlet to the mains, the amount of loss depending upon the ratio of the quantity of water forced through the pipe to the size of the pipe. The larger the pipe for a given demand, the smaller the friction. To obtain this loss from friction, first find the velocity of the water in the pipe in feet per second by dividing the quantity of water passing through the pipe by the area of the pipe, all dimensions being expressed in feet. Then the loss of head per 1,000 feet of pipe equals 62.1 $m\frac{v^2}{d}$, where m averages .0064 for 6-inch pipe, .0055 for 12-inch pipe and .0050 for 18-inch pipe; v = velocity in feet per second; and d = diameter in feet. With the maximum velocity that should be allowed in designing, 3 feet per second for a 6-inch pipe and 5 feet per second for a 12-inch pipe, the loss in head will be about 8 feet per 1,000 feet of main. For long mains this should be reduced by using larger pipes. Adding this loss of head to the effective head at the hydrant gives the head required at the inlet. The necessary pressure per square inch by direct pumping will be found by multiplying this height in feet by .434.

Comparison of Different Systems of Supply.—The flat site of the ordinary Illinois town will determine that either the modified gravity system or the direct-pumping system be used. Each has its advantages under different circumstances. The stand-pipe system has the advantage over the direct-pumping system of maintaining a nearly uniform pressure on the mains. The tower acts as a regulator. With the ordinary direct-pumping engine when a large consumption of water is suddenly shut off, the increased strain on the mains is very great, so that the pipes often burst. For this reason a smaller main may be laid from a stand-pipe than with the direct-pumping system. Even with the stand-pipe system the hydrant must be devised to shut off the discharge slowly. Another advantage of the stand-pipe system is that the expenditure for pumping machinery is less. If the stand-pipe be tall enough to furnish ordinary fire protection, the engine need not be run all the time, making a saving of wages, &c. In case of a break in the machinery, a short delay in making repairs will not interfere with the supply of water. This is an important item. Machinery for the direct-pumping system must be proportioned for furnishing the maximum hourly water supply and the engines must be duplicated, thus increasing the cost.

The direct pumping system is well represented by the Holly system. The advantages of this are,—a saving of the cost of a stand-pipe; an automatic regulation of the engines to change immediately for sudden differences in the demand for water; prompt and efficient increase of pressure at time of fires; the great economical feature of ordinarily only forcing the water through the mains at the level of the city, instead of raising it all 200 feet above that level, whether it all be so required or not. By a duplication of machinery, one set

may be at work while the other is undergoing repairs. The danger of a total failure of the machinery is lessened and practically overcome by having duplicate parts for those liable to wear or to break.

In brief, the former has greater certainty of continuous supply; the latter, economy of construction and operation.

The method of pumping into a reservoir at the level of the city, and then using direct pressure through the mains is a modification of either, and is efficient where the source of supply is a deep well.

Stand-pipes.—The numerous failures of stand-pipes during 1886 give evidence of faulty designs. The structures at Gravesend, L. I., Victoria, Texas, and Kankakee, Ill., were deplorable pieces of engineering. Great improvements might be made on any of the existing designs. In the ordinary stand-pipes the greatest weakness is in the joints. The specifications should require that the rivet holes be drilled, or that the iron be warm when the holes are punched and that it afterward be annealed. The latter process will restore the strength lost by punching.

The following method of proportioning plates may be used:

The pressure per sq. in. = height of water in feet $\times$ .434. This pressure multiplied by the diameter expressed in inches gives the total pressure in one direction on a ring one inch high. This stress is resisted by the thickness of the plates on the two opposite sides. Calling t the thickness of plate, S the allowable stress on the iron per sq. in., h the height of water above the section considered, and d the diameter, we have

$2\,t\,S = .434\,h\,d$, when h is in feet and d in inches. The resulting value of t in inches when h and d are in feet will be

$t = \dfrac{2.6\,h\,d}{S}$. For the solid plate of wrought iron, 12,000 would be a safe value for S. The riveted joint is weaker than the solid plate by the ratio of the diameter of the rivet to the distance between the centers of rivets, and the joint must be strong enough, even if its size is accompanied by great waste of material in the plate away from the joint. So a value for S should be used equal to that for the solid plate multiplied by the quotient of the difference between the distance from center to center of rivets and the diameter of rivets, divided by the distance between rivets. For best proportioned double-riveted lap joints with drilled holes, and good workmanship, 10,000 may be used, and no further allowance for the holes made. To make the loss of material as little as possible, the lap joint must be double riveted. Strict inspection of the work must be made, for the joint is weak enough at best and the tendency to poor workmanship in this is greater than in almost any other work. In using the above formula, take the distance from the top of water to the bottom of each plate, calculate the size of the plate, and use the nearest size of iron above that.

For the horizontal joints, the wind pressure should be considered. Let h=height above the point considered, d=diameter, t=thickness of plate, s=working stress of the iron per sq. in., w=pressure of wind per sq. ft.

The moment of inertia, I, of a hollow cylinder is approximately $\frac{1}{8}\times 3.1416\, d^3t$. Th emoment of resistance$=\frac{S\,I}{\frac{1}{2}d}=\frac{3.1416\, d^2\, t\, S}{4}$. Since the effect of wind on a cylinder is equal to $\frac{2}{3}$ that on a plane of equal height, and width equal to the diameter, we have

Bending Moment of Wind $= \frac{1}{2} h \times \frac{2}{3} d\, h \times w = \frac{1}{3} d\, h^2 w$. For a stand-pipe in an exposed situation, especially with the increased cumulative vibratory motion caused by the repeated gusts of wind, a wind pressure of 50 pounds per square foot should be allowed for. Using S = 10,000 pounds per square inch—a fair value for wrought iron subject to shocks—this formula reduces to

t *in inches* $= \frac{1.8\, h^2}{d\times 10{,}000}$. This is for solid plate. For the joints, this numerical factor of the denominator must be multiplied by the quotient found by dividing the distance between centers of rivets less the diameter of rivets, by the distance between centers of rivets, to allow for the loss in plate from the rivet holes. Thus if the rivets are 1 inch in diameter and $2\frac{1}{2}$ inches between centers, we have for that factor $10{,}000 \times \frac{2\frac{1}{2}-1}{2\frac{1}{2}}$ =3-5$\times$10,000=6,000. For properly proportioned single-riveted lap joints this will reduce to $t = \frac{1.8\, h^2}{d\times 6{,}000}$, and for double-riveted $t=\frac{1.8\, h^2}{d\times 8{,}000}$.

The above applies to the pipe when filled with water. For the portion not filled with water, the resistance to flexure, on account of the tendency to collapse, is much less than this. No adequate experiments have been made on this subject. Fairbairn experimented on smaller tubes with exactly similar proportions of length, diameter and thickness of metal to those ef stand-pipes, and his results interpreted give an average value of 3-10 the strength of pipes not subject to collapse. For the intermittent strains and impact of wind storms, 2-10 of the numerical factor should be used. This will give the formulæ for thickness of solid plate, of plate with double riveted joint, and of plate with single riveted joint, respectively, as follows:

$$t=\frac{1.8\, h^2}{d\times 2000},\quad t=\frac{1.8\, h^2}{d\times 1600},\quad t=\frac{1.8\, h^2}{d\times 1200}$$

These are to be applied to the bottom of each plate as low as the pipe may be emptied.

All the above formulæ are for safe load and not for breaking load. The factor of safety, as the term is usually employed, ranges from $4\frac{1}{2}$ to $5\frac{1}{2}$. For steel proportionately larger values of S should be used.

The latter formulæ will often in stand-pipes of large diameter diameter give smaller results than the thickness required by the

pressure of water, and the latter will be the governing consideration.

The foundation anchor bolts must be proportioned to resist the lifting strain caused by the wind, and calculated from the formula for wind pressure, and must be well built into the foundation. In the Kankakee stand-pipe these rods were made bent, and after the pressure had straightened them, the resulting play, with the impact from the swaying, increased the pull on them many times, so that it is no wonder they gave way. It would be economy to use lateral brace rods extending from a point half-way up the tower and anchored in the ground at a proper distance. Generally the foundation is not broad enough, and is not properly built. The masonary should be of good stone, with the best cement, and must especially be laid in a workmanlike manner. In this, as in all other specifications, the tests and inspections should be thoroughly made. Manufacturers agree to rigid specifications expecting that there will be no tests. Specifications ignored are worse than useless, for they leave us with a false opinion of safety.

Rainfall as affecting size of sewers.—There is no uniformity in practice in proportioning sewers to carry off the rainfall. In Washington, D. C., the government engineers with their usual prodigality designed the sewers to carry off 2 inches of rainfall per hour, or, as they expressed it, made them large enough for a 3-inch rainfall, provided only two-thirds of it reached the sewer. Their records for 13 years showed 10 storms at the rate of over 1 inch per hour. As these did not last through the hour, and as only a portion of the water reached the sewer within the duration of the storm, the allowance is certainly too large. St. Louis sewers are designed to carry per hour a quantity 1 inch in depth over the area drained, and it is claimed that experience has proved this to be suited to the local circumstances. The record of the United States Signal Service in Chicago, for the 12 years from 1872 to 1883, shows that there were but five days when the rainfall in 24 hours exceeded 3 inches, and but one when it exceeded 4 inches. In only one shower did the rainfall for the duration of the storm average $\frac{3}{4}$ of an inch per hour, and in only three or four did the average rate exceed $\frac{1}{4}$ inch per hour. It was recommended that the main sewers of Hyde Park be constructed to carry 1-12 of an inch per hour, and the laterals $\frac{1}{8}$ of an inch per hour. This may be large enough for very large areas of open flat land.

The amount to be allowed depends upon the location. Districts built up compactly and having streets and yards paved will discharge the storm waters much more rapidly than the unpaved and thinly settled districts; and locations having rapid fall from the elementary drainage areas to the sewer inlets will require more water-way than flat districts. Likewise in very large areas, the storm water nearest the outlet will be nearly all discharged, and the worst of the storm over before that from the head of the sewer will have reached that point; therefore, a long main sewer will receive a proportionately smaller amount of storm water than a short and lateral sewer. I

should recommend that for sewers draining a compactly built portion of small area, having all streets paved, one-half of an inch and one inch be the limits of allowance for rainfall per hour, the former for flat and the latter for rapidly sloping surface. For the residence portion $\frac{1}{4}$ inch to $\frac{1}{2}$ inch, the former for flat and unpaved localities and the latter for paved streets and sloping surface. In any case the topography and all local circumstances must be considered.

A. N. TALBOT, Chairman.

REPORT

OF THE

THIRD ANNUAL MEETING

OF THE

ILLINOIS SOCIETY

OF

ENGINEERS AND SURVEYORS,

HELD AT

Springfield, Ill., Jan. 25, 26 and 27, 1888.

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OFFICERS.

President, C. G. ELLIOTT, Gilman, Ill.
Vice-President, D. W. MEAD, Rockford, Ill.
Executive Secretary, PROF. A. N. TALBOT, Champaign, Ill.
Recording Secretary, S. A. BULLARD, Springfield, Ill.
Treasurer, PROF. A. N. TALBOT, Champaign, Ill.

EXECUTIVE BOARD.

A. H. BELL, Chairman, E. A. HILL, C. G. ELLIOTT, G. P. ELA, A. N. TALBOT.

STANDING COMMITTEES.

Legislative and Judiciary Committee—Charles Hansel, Z. A. Enos, Wm. D. Clark.

Committee on Land Drainage and Public Highways—E. J. Chamberlain, John R. Lewis, Joseph L. Clark.

Committee on Land and City Surveying—A. H. Bell, Daniel H. Davison, Geo. K. Wheelock.

General Committee on Engineering—C. W. Clark, W. S. Shields, Prof. J. B. Johnson.

Committee on Mining Engineering—Prof. T. B. Comstock, Thomas Hudson, F. K. Copeland.

Committee on Municipal Engineering—D. W. Mead, W. W. Abell, J. W. Alvord.

Committee on Instruments, Blanks and Records—Prof. I. O. Baker, Geo. H. Whittaker, D. L. Braucher.

SPECIAL COMMITTEES.

Committee on National Public Works—Geo. P. Ela, Geo. F. Wightman, T. S. McClanahan.

Committee on Weights and Measures—J. T. Foster, D. J. Stanford, F. V. Alkire.

Committee on Exhibit and Exchange of Drawings—A. N. Talbot, S. F. Balcom, D. W. Mead.

MEMBERS.

W. W. Abell..........Elgin.
City Engineer.

Frank V. Alkire..........Petersburg.
Deputy County Surveyor.

*A. S. Aloe..........300 N. 4th street, St. Louis, Mo.
Mathematical Instrument Maker.

John W. Alvord..........Lake View.
City Engineer.

I. O. Baker..........Champaign.
Professor of Civil Engineering, University of Illinois.

S. F. Balcom..........Champaign.
Assistant Engineer, I. C. R. R.

A. H. Bell..........Bloomington.
City Engineer and Drainage Engineer.

Clarence Brainard..........Buda.
Civil Engineer.

A. C. Braucher..........Canon City, Col.
Assistant Engineer, Canon City Coal Co.

D. L. Braucher..........Lincoln.
Civil Engineer and Surveyor.

S. A. Bullard..........Springfield.
Architect and Sanitary Engineer.

J. W. Burnham..........Bloomington.
Agent King Iron Bridge Co.

J. S. Burt..........Henry.
County Surveyor, Marshall County.

Jos. E. Burtle..........Pawnee.
Engineer and Surveyor.

C. W. Clark..........American Central Building, St. Louis, Mo.
U. S. Assistant Engineer.

G. M. Clark..........Low Point, Woodford County.
Drainage Engineer.

J. L. Clark..........Momence.
County Surveyor and Civil Engineer.

W. D. Clark..........Springfield.
City Engineer.

E. J. Chamberlain..........Pittsfield.
Engineer Sny Island Levee Repairs.

S. C. Colton..........217 E. Ohio street, Chicago.
Engineer with The Fitz Simons & Connell Co.

T. B. Comstock..........Champaign.
Professor of Mining Engineering, University of Illinois.

* Associate Members.

F. K. Copeland .... 22 W. Lake street, Chicago.
Vice-President Diamond Prospecting Co.

J. K. Croswell .... Kankakee.
Civil Engineer and Surveyor.

D. H. Davison .... Minonk.
Surveyor.

G. W. Dickinson .... Shelbyville.
County Surveyor, Shelby County.

Nicholas DuBois .... Springfield.
Civil Engineer and Accountant.

Joel Dunn .... Bement.
Drainage Engineer.

G. P. Ela .... Bloomington.
Surveyor and Civil Engineer.

C. G. Elliott .... Gilman.
Civil and Drainage Engineer.

Z. A. Enos .... Springfield.
Surveyor.

Jacob T. Foster .... Chicago.
County Surveyor and Civil Engineer.

James Freer .... Peoria.
State Mine Inspector.

B. J. Gifford .... Rantoul.
Capitalist.

Daniel Gordon .... Moline.
County Surveyor and Civil Engineer.

Richard Gray .... Bloomington.
Civil Engineer.

Samuel S. Greeley .... 60 Bellevue Place, Chicago.
Surveyor and Civil Engineer.

Charles Hansel .... Springfield.
Engineer Wabash R'y.

Alexander Hamilton .... Salem.
County Surveyor, Marion County.

J. M. Healey .... Champaign.
Division Engineer I. C. R. R.

Tony Hefel .... Vandalia.
County Surveyor and Civil Engineer.

E. A. Hill .... Indianapolis, Ind.
Chief Engineer, I., D. & S. R'y.

S. N. Howard .... 834 Opera House Block, Chicago.
Surveyor, and Secretary Greeley-Carlson Co.

Thomas Hudson .... Galva.
State Mine Inspector.

J. B. Johnson .... St. Louis, Mo.
Professor of Civil Engineering, Washington University.

*T. L. Johnson .... Philadelphia, Pa.
Agent J. W. Queen & Co.

O. Jones .... Cambridge.
Surveyor.

William Kilgore .... Rose Hill.
County Surveyor, Jasper County.

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* Associate Members.

J. S. Lane..Chicago.
General Superintendent M. C. Bullock M'f'g Co.

Charles Levings..Chicago.
Chief Engineer Chicago & Atlantic R'y.

John R. Lewis..Piper City.
Surveyor and Civil Engineer.

George V. Loring..Decatur.
Surveyor and Civil Engineer.

Nath'l McBride..Morris.
County Surveyor and Civil Engineer.

T. S. McClanahan..Monmouth.
County Surveyor and Civil Engineer.

D. McNabb..Tonica.
Surveyor.

D. W. Mead..Rockford.
City Engineer.

Archibald Means..Peru.
Zinc Manufacturer.

L. S. Meredith..Fairfield.
County Surveyor.

Clarence E. Messer..Onarga.
Surveyor.

E. L. Morse..Cazenovia.
Resident Engineer, I. V. & N. R. R.

Jay C. Morse..............................302 First National Bank Building, Chicago.
President Union Steel Co.

H. C. Niles..Tuscola.
Surveyor and Civil Engineer.

Frederick Rottman..LaSalle.
City Engineer.

Walton Rutledge..Alton.
State Mine Inspector.

W. S. Shields..............................69 Ashland Block, Chicago.
Civil Engineer and Surveyor.

L. N. Sizer..Mahomet.
Drainage Engineer.

Kirby Smith..Mt. Vernon.
County Surveyor, Jefferson County.

D. J. Stanford..Chatsworth.
County Surveyor and Civil Engineer.

Hubert A. Stevens..............................145 Loomis street, Chicago.
Civil Engineer, Department of Public Works.

A. N. Talbot..Champaign.
Assistant Professor of Engineering and Mathematics.

Geo. K. Wheelock..Normal Park.
City Engineer.

E. H. Whitaker..Peru.
Drainage Engineer.

Noah Whitley..Joliet.
City Engineer.

Geo. H. Whittaker..Pittsfield.
County Surveyor and Civil Engineer.

GEO. F. WIGHTMAN .... Peoria.
City Engineer.

ROBERT WINNING .... Cartersville.
State Mine Inspector.

J. WITHINGTON .... Mattoon.
Surveyor.

NEWTON YOUNG .... Yorkville.
County Surveyor, Kendall County.

J. O. WRIGHT, ... La Fayette, Ind.
Civil Engineer.

HONORARY MEMBERS.

F. HODGMAN .... Climax, Mich.
EZRA D. SHREVE .... Bucyrus, Ohio.
FRED. J. SAGER .... Columbus, Ohio.

Attention is called to the notice of the Fourth Annual Meeting to be held in Bloomington in January, 1889, as given on page 158

PROCEEDINGS

OF THIRD ANNUAL MEETING OF

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS,

—HELD AT—

SPRINGFIELD, ILL., JANUARY 25--27, 1888.

WEDNESDAY—EVENING SESSION.

The society met in the senate chamber of the State House at 7:30 p. m., with President Baker in the chair. After offering a greeting to all, the President delivered his annual address. The report of the Executive Secretary was read and approved.

The following communication was read by the Secretary:

To the President and Members of the Illinois Society of Engineers and Surveyors:

I see upon your programme a portion of your exercises here will be a visit to the rolling mills of this city. If it meets with your convenience and pleasure the Wabash Railway will place at your command an engine and coach, by which means you may most conveniently have access to the mills, starting from the Wabash passenger depot, corner Tenth and Washington streets.

I trust it will be your pleasure to accept.

Fraternally Yours,
CHARLES HANSEL,
Chief Engineer Wabash Railway.

On motion the proposition of Mr. Hansel was accepted, and the hour of 3 o'clock p. m., Thursday, set for the time of starting from the depot.

The Executive Board reported they had approved the applications of the following named gentlemen for members of the society, who on vote by ballot were elected:

Abell, W. W	Elgin
Alvord, J. W	Lake View
Burnham, J. H	Bloomington
Burtle, J. E	Pawnee

Clark, J. L........Momence
Clark, W. D........Springfield
Copeland, F. K........Chicago
Davison, D. H........Minonk
DuBois, Nathaniel........Springfield
Freer, James........Peoria
Hammond, C. L........Chicago
Hansel, Charles........Springfield
Hudson, Thomas........Galva
Kilgore, William........Rose Hill
Lane, J. S........Oak Park
Levings, Charles........Chicago
McBride, N........Morris
McNabb, D........Tonica
Means, Archibald........Peru
Morse, Jay C........Chicago
Niles, H. C........Tuscola
Rottman, Frederick........LaSalle
Rutledge, Walton........Alton
Shields, W. S........Chicago
Wheelock, G. K........Normal Park
Whitaker, E. H........Peru
Whitley, Noah........Joliet
Whittaker, Geo........Pittsfield
Winning, Robert........Carterville

Chairman Clark reported for the General Committee of Engineering.

By request, Mr. Healy's paper on the Importance of Replacing Wooden Trestles with Iron and Stone Structures was read by Mr. Balcom. Discussion.

On motion the following committee was appointed to make a display of such drawings as had been brought or sent in by the members: S. F. Balcom, F. V. Alkire and W. D. Clark.

On motion the hour for meeting at the morning session was fixed at 9 o'clock.

THURSDAY—MORNING SESSION.

On motion S. A. Bullard and D. L. Braucher were appointed a committee to conduct Governor Oglesby to the hall for the purpose of delivering an address to the society.

The paper, Surveying—Practical and Artistic, was given by D. L. Braucher. Discussion.

Governor Oglesby then gave an address of twenty minutes' length, in which he welcomed the society to the city, contrasted the present age of specialties with forty years ago when a man was as well fitted for one occupation as for another and changed accordingly, reviewed the advance of engineering, referred to the directions in which there was still room for advancement, suggested the farther

exploration of the earth's interior, and predicted that there would never be any end to advancement in engineering. President Baker made a happy response.

The paper by J. H. Burnham on Interest of Engineers and Contractors in Improved Bridges was read and discussed.

On motion a special committee was appointed to draft suitable resolutions on the death of member R. N. Johnson, of Norris City, Illinois, which occurred December 31, 1887,—Geo. M. Clark, G. P. Ela and A. H. Bell.

The President appointed T. S. McClanahan, J. R. Lewis and H. C. Niles a committee to decide upon questions of practice in land surveying.

Paper by Mr. McClanahan on Laying out Towns and Perpetuating Monuments. Discussion.

AFTERNOON SESSION.

S. F. Balcom read his paper on the Progress of the Cairo Bridge over the Ohio River.

The society then adjourned and visited the rolling mills, the watch factory and other points of interest under the guidance of the local members.

EVENING SESSION.

Paper by I. O. Baker on Specifications for Bridge Iron was read and discussed.

A report was given by the committee on Municipal Engineering through Chairman D. W. Mead. Discussion.

Paper by E. A. Hill on A Railroad Culvert was read and discussed.

F. V. Alkire read his paper on Mine Surveying. Discussion.

FRIDAY—MORNING SESSION.

President Baker called Mr. Hill to the chair.

A supplemental report was received from the committee on Municipal Engineering proposing an interchange of drawings of work in process of erection or construction, and recommending that a committee be appointed to carry out the plan suggested. Approved, and a motion passed to appoint such a committee. A. N. Talbot, D. W. Mead and S. F. Balcom appointed.

Paper by Dr. G. N. Kreider, Sanitary Engineering and Architecture, was read and discussed.

The Executive Board made partial report and stated that the Executive Secretary had been paid sixty dollars for services during last year, but that sum would not compensate him during the coming year. The board referred the matter to the society. On motion the salary of the Executive Secretary was made one hundred and fifty dollars per year.

The report of the Legislative and Judiciary committee after discussion was approved. On motion the society recommended the advocacy of the bill mentioned in the report of the committee.

A paper on Artesian Wells was delivered by Prof. Comstock, followed by a paper by A. C. Braucher on the Coal Fields of Colorado and New Mexico.

On motion the President appointed Prof. Comstock and D. L. Braucher a committee on nomination of officers.

AFTERNOON SESSION.

J. O. Wright delivered his paper, How to Secure Better Highway Bridges. Discussion.

Prof. Baker exhibited a tabulated statement of the Range of the Magnetic Declination.

The committee to whom were referred Practical Questions in Land Surveying reported through Chairman McClanahan.

Chairman Elliott reported for the committee on Land Drainage and Public Highways.

Paper by Mr. Enos, The Township Boundary, was read by the Secretary.

The paper, Bridges and Viaducts for Small Cities, by Mr. Mead, was on Mr. Mead's motion read by title and referred to Executive Board for printing.

Chairman Comstock reported for the committee on Mining Engineering.

The following resolution was offered by Mr. Braucher, who moved its adoption:

Resolved, That the hearty thanks of this society be and are extended to Mr. Charles Hansel, chief engineer of the Wabash Railway, for his courtesy in providing the society with a special train by which to visit the rolling mills.

Adopted.

The committee on National Public Works reported through Chairman Ela.

The special committee to draft suitable resolutions on the death of Member Johnson made their report and the sketch of his life was read.

After nominations were reported by the committee, I. O. Baker was chosen President, but he declined to serve a third term and new nominations were made. C. G. Elliott, of Gilman, was finally elected.

The results of the ballots on the other officers were as follows:

Vice-President	D. W. Mead, Rockford
Executive Secretary	Prof. A. N. Talbot, Champaign
Recording Secretary	S. A. Bullard, Springfield
Treasurer	Prof. A. N. Talbot, Champaign
Executive Board	Geo. P. Ela, Bloomington, A. H. Bell, Bloomington, E. A. Hill, Indianapolis, Ind.

Bloomington was chosen for holding the next annual convention.

Prof. Comstock introduced the following amendment to the constitution, which under the rules was referred to the Executive Board:

AMENDMENT TO CONSTITUTION.

To Art. IV. add Section 6, as follows: At each annual meeting the President shall also arrange, if possible, to secure the attendance of one member of the society at each meeting of other State societies whose publications are given in exchange for the publications of this society; it being stipulated that no expense shall be incurred in this business without the express sanction of the Executive Board, and in no case shall such expenditure be so authorized unless there be a surplus at the time in the treasury above all existing claims

On motion J. H. Burnham and Noah Whitley were appointed a special committee to assist the Executive Secretary in soliciting advertisements for the next annual report.

Prof. Comstock offered the following resolutions, which were unanimously adopted:

Resolved, That we offer most hearty thanks and record our sincere appreciation of the very cordial reception extended to this society as a body and to each and all of us as individuals by the citizens of Springfield, and especially of the valuable services rendered by our local members, and the hearty greeting extended to us by Governor Oglesby.

Resolved, That we regret our inability to accept the warm invitation to meet here in 1889, but that we shall always be as ready to return as they are to receive us.

Installation of new officers, congratulations, speeches, and adjournment *sine die*.

S. A. BULLARD, *Recording Secretary*.

PRESIDENT'S ADDRESS.

PROF. IRA O. BAKER, OF CHAMPAIGN.

Gentlemen of the Illinois Society of Engineers and Surveyors:

A year ago your President hesitated as to which general form of annual address would be most satisfactory to the members of this society; he finally decided in favor of a summary of engineering progress during the year then just past. This was done without a full appreciation of what was expected in the report of our standing committees, as called for in our order of business. The subjects assigned to the standing committees cover a wide range, and, since the members of these committees have been selected because of their special interest in the respective topics, your President does not consider it wise, even if he were competent, to attempt a general summary which would either be fragmentary or traverse the ground covered by the reports of the several committees. The reports presented last year by these committees were such as to warrant the society in looking to them for a record of the most important occurrences in their respective departments.

The place of our present meeting, the capitol of the state, suggests to your President that, while all citizens owe duties to the commonwealth, each owes certain special duties peculiar to his own particular walk in life; thus, the physician, by virtue of his especial knowledge as such and also owing to his daily occupation, owes it to the community to give timely warning of the possibility of an outbreak of an epidemic and also to suggest measures which may either prevent or ameliorate its visitation. So, too, if the lawyer, as a result of his experience, believes that certain modifications in the machinery of the courts would better serve the ends of justice or secure to the body politic a greater economy in the conduct of litigation, he owes it to society to make public his beliefs and also to assist in securing the desired result. The desirability of the proposed changes and the probability that the means proposed will secure the object aimed at, should be considered on their merits; if it can be shown that the changes proposed are likely to prove beneficial to the community at large, then all right and proper means should be employed to bring about the necessary modifications, even though the claim may be made that such changes will be of more advantage to one class than to another and even though the accusation be made that changes were proposed solely because of the benefit likely to accrue to this same class.

With your permission, the President will call the attention of

the members of this society to a few changes which he sincerely thinks will be to the best interest of the commonwealth. The advocacy of some of these innovations may be open to the accusation that they are in the interests of the members of this society as a special class; but the speaker desires to have it distinctly understood that, if the changes proposed be not in the interests of the community at large, then let no one utter a word or move a finger toward bringing them about. Do not let me be understood as claiming that this society is not organized and maintained for the improvement and benefit of its individual members; but, on the other hand, we do not propose to seek these ends in any trades union spirit. These topics are discussed here that the thought of the members may be directed to these channels and with the hope that we may all get clearer ideas as to the objects to be accomplished and of the best means to be used. Although a sudden or radical change can not be hoped for, nor is it desirable, yet continual agitation and discussion will evolve a feasible solution.

The first item to which your attention is asked is

OUR HIGHWAYS.

Probably no state in the country has roads that are in a worse condition for six months of the year than Illinois. The soil is remarkable for its productiveness, but when mixed with even a small proportion of water, it makes an equally undesirable material for the surface of a wagon road; it would be difficult to imagine a worse. The greatest drawback toward the improvement of the highways has been the indifference of the very class of men to be benefited, more than any others, by such improvements. The more enlightened and progressive farmers are beginning to realize that good roads are essential not only to the economical transportation of product, but also to the development of the community in all respects; but, as a class, the farmer is loth to tax himself in labor or money for the improvement of the highways, and probably never will until he is compelled to.

The country authorities must first be taught what good roads mean; and this is a work that our members can do as opportunity offers. It is not necessary to repeat the advantages of good country roads, nor to point out the defects of the present system, or rather lack of system, of caring for them. When the real benefits are once apparent, the more enlightened of the farmers will themselves demand compulsory improvement on the slipshod methods of today.

We must first have wisely framed laws that will introduce some system and responsibility into this matter; and not leave it, as now, in the hands of private citizens, locally and temporarily appointed, and without the technical training required or even an appreciation of the value of such training. Such a system was proposed and earnestly and ably advocated by the Secretary of the State Board of Agriculture at the Highway Convention in this city two years ago.

The proposition was to employ a competent engineer who should have supervision of the highways of a county or township. "On the Continent of Europe and in England the construction and proper maintenance of highways is a State affair; their superintendence is recognized as an important and responsible duty, and we usually find them in charge of specially trained, expert government engineers. The result is magnificent roads, of a degree of excellence of which we Americans have no conception, because, outside of mere pleasure drives, they nowhere exist with us. Our roads are too many and too long, and the tax would be too great upon our people, to at once demand even a distant approach to continental highways in point of construction and maintenance. But we are growing richer every day—are in fact the richest nation on the face of the earth—and it is high time we made a beginning, at least, in the improvement of our highways. They are probably the one thing most neglected in our rapid advance in almost every other direction. As we are daily adding to our list of luxuries, if good roads must be classed among these, let us have them."

In many localities the nature of the soil and the absence of suitable material with which to construct permanent roads, makes the maintenance of highways, in even comparatively good condition, a problem equally as difficult and fully as important as the maintenance of the road-bed of a railroad. The attention of the members of this society is called to this new engineering field. It may not seem as glorious as building trans-continental railroads, nor as lucrative as working on isthmian canals, but it is honorable, requires as much talent as most of the positions on larger enterprises, and will in the long run prove as remunerative. The world sounds the praises of the man who built the great East River bridge, and also of the man who opened the mouth of the Mississippi river, but he who devises and introduces a successful system of caring for our country roads will be deserving of far greater praise. At present our efforts should be directed to the creation of a public sentiment which shall demand the laws necessary to secure better highways. From time immemorial the drainage law and the road law have been the subjects of interminable discussion and untold, and often unintelligible, amendments and modifications; if a road law can be secured which will prove as beneficial as is the present drainage law, it will be a wonderful improvement upon the present methods.

The second item to which your attention is asked, is

HIGHWAY BRIDGES,

a question in its main characteristic similar to the one just considered, but one pertaining more to the present than to some hoped for utopian future. Those in charge of our highways are already seeking to secure some improvements hinted at in the preceding discussion. In many localities, as fast as the early wooden bridges become too weak, owing to age or to heavier traffic, the old structures

are being replaced with iron ones. This is commendable, but it is unfortunate that the means are not as commendable as the intentions. What man would ever think of giving an order for a coat to an unknown tailor without any guaranty as to quality of cloth, fit of the garment, or workmanship, except perhaps to specify that it shall be a cloth coat and that it shall reach from neck to knee; and then when the work was done, pay possibly fifty per cent. more for the garment than the best coat of the kind desired could be had for. It is susceptible of demonstration that in many, and perhaps most, cases this is a close parallel to what highway commissioners do in purchasing iron bridges for our country roads.

Of course, it is always agreed that it shall be "an iron bridge;" but there is iron and *iron* and BRIDGE IRON, as there is mosquito-netting and muslin and ducking. If a man were ordering a coat, he would be particular to specify the kind or quality of material to be used, since he knows that there is shoddy cloth and good cloth; so too there is shoddy iron and good iron. Even good iron is made of different qualities for different purposes. If the bridge were to be of wood, the buyer would certainly specify that the timber should be oak or pine—straight-grained, free from knots and sap—and he would not accept brash or cross-grained cottonwood instead. Yet there is more difference between iron, and iron, than between any two varieties of timber. For example, Wood's Resistance of Materials gives a table of strengths of materials in which the highest value for timber is three times the lowest, and the highest for iron is six times the lowest; if we include steel under the name iron, as is frequently done and as would be proper in this case since the average highway commissioner could not tell the difference, then the highest is eight times the lowest; if cast iron be included simply as iron, as for this comparison there is reason for so doing, then the highest is about sixteen times the lowest. How foolish it is then to say simply an *iron* bridge.

Again, when the highway commissioner orders a coat, he pays little or no attention to the strength of the cloth, but applies certain tests to determine its probable wearing qualities and its suitability to the service desired; he knows that the strongest cloth is not necessarily the best cloth. Iron suitable for bridges should have qualities somewhat similar to that possessed by cloth suitable for a coat. Nearly all men have had sufficient experience to enable them to select cloth with a reasonable degree of certainty of getting a good article, while only those who have made a special study of iron are competent to determine the suitableness of iron for the service proposed.

When the coat is finished, the commissioner is particular to see that the cloth is that which he selected, and not some other kind of lighter weight; but he rarely applies these sound business principles to the inspection of the bridge which he buys. He will reject the coat, if it is sewed with rotten thread, but is oblivious to the fact that most highway bridges are sewed with very rotten thread. The

manner of connecting the several pieces of a bridge is the most vital part, and the determination of the strength of this element requires great skill.

Of course the contractor says he will make a good bridge, but as his interests lie in getting a cheap one would it not be wise to see if the structure is really a good? When a financial agent passes in his accounts, they are inspected by some competent person; when goods are received, they are counted or weighed before the bill is paid. But usually there is no pretence of testing a highway bridge, and if there is it generally does more harm than good. The bridge may be tested and stand up under a heavy load, but the very act of testing it may, and doubtless often does, partially destroy the structure; the heavy test load may overstrain the material—virtually cracking the pieces—after which a few lighter loads will complete its destruction. Such tests give a feeling of security that in fact does not exist. Nearly all bridges which break down, fail under a light load which follows a heavier one. Again the absolute weight of the test load is not the only important item. The failure a few years ago of the highway bridge at Dixon, this state, which was accompanied by great loss of life, was due not to the magnitude of the load but to its position; probably the bridge would not have failed under double the load. A bridge can be tested, and that too without damaging it, so as to determine with almost absolute certainty whether it is sufficiently strong for the service demanded.

The failure of highway bridges is not so rare an occurrence as may at first be thought. Over twenty highway bridges fall in the United States each year; in proportion to their number and to the travel upon them, they are far more prevalent than railroad bridge disasters. The people complain, and properly, if the railroads do not take every reasonable precaution to insure safety to travelers; but they are singularly indifferent to the safety of their own bridges. Bridges will occasionally fail from unforeseen causes, and it is not wise, nor prudent, to spend a greatly increased sum to secure absolute safety; but it is wise, and also a duty, since human life may possibly be involved, to provide for all probable contingencies. At present most highway bridges fail to provide even a reasonable degree of security. It is a perfectly well-known fact that nine out of ten of the highway bridge disasters, so common in this country, can without the slightest question be prevented if those who have charge of the bridges care enough about it to do it.

The evil effects of the present system can be eliminated only by a complete reform in the present system of buying highway bridges. The first error is in advertising lettings only in the local newspapers; they should be advertised in the newspapers which make a specialty of that kind of advertisments and which reach the men who make a specialty of building bridges.

A second, and greater, mistake is not having the bids inspected and compared by a competent engineer; there may be a great differ-

ence in value between two coats, particularly if one is made to wear and the other to sell. The railway officials employ skilled men to inspect the bids for their bridges, who go over the plans with the minutest care; consequently, none but competent and honest builders bid for railroad bridges. It is well known that highway commissioners do not employ such skill; consequently, the tendency is to induce all incompetent and dishonest bridge builders to give their attention exclusively to highway structures. Is it unreasonable to believe that there are incompetent and dishonest bridge builders? Is it unreasonable to believe that a dishonest or incompetent builder, knowing that neither his plans nor bridge are to be inspected by a competent man, will not fail to make his price so low that it will be lower than a good bridge can be had for? Is it unreasonable to believe that under these conditions honest and competent builders will be reluctant to bid? Is it wise to do business in a way to repel the reputable manufacturer and set a premium upon dishonesty and incompetency?

A few years ago an iron bridge was built in one of the Middle States which was guaranteed by the makers to carry a far heavier load than even the best iron could possibly have stood. After a long controversy, the bridge was condemned, removed, and replaced by a better one. The condemned bridge was afterwards again sold by its original builders, without any alteration whatever, and guaranteed to carry safely a load greater by one-third than the bridge was first guaranteed to carry. There is plenty of unquestionable evidence to show that there are many examples of wickedness and ignorance in highway bridge work.

A word concerning the cost of bridges. The evidence seems to be sufficient to prove that bidders, after having made out their bids upon a business basis, frequently meet in private session and by agreement increase their price as great a per cent. as in their judgment the job will stand. Your president has private information that recently in this state a bridge was awarded on a bid that had been thus increased 50 per cent. He also knows of a county in which the average price paid for highway bridges is about 100 per cent. more than is paid in the adjoining county, both being equally favorably situated as to freights, &c.

There are several other ingenious tricks employed by highway bridge builders to impose upon and defraud town and county officers, which would be too tedious of explanation for insertion here. As engineers we should be interested in reforming the present system of building highway bridges; as tax-payers, we should be interested in the application of sound business principles to the purchase of highway bridges; as, men, we should be interested in seeing that our highway bridges are reasonably safe. In many instances the law prescribes in detail concerning the expenditure of public money, and it would be admissible to enact a law to cover the evils in the present practice of building highway bridges; but with the present state of public opinion, such a law would be a dead letter and therefore worse

than none. The first step in this reform is to make the public acquainted with the evils of the present system. When the disease is fully recognized, and not till then, will the public demand a cure. In case of an accident, or of needless expenditure of public money, the commissioners should be held to a strict accountability.

Another matter not remotely connected with the preceding is the term

FACTOR OF SAFETY.

Any comments upon this threadbare subject may be considered by some as simply shooting at a dead dog, but as some do not know he is dead, we will use him as a target for rifle practice.

The term "factor of safety" is usually defined as being "the ratio of the computed strain to the actual strain; or in other words, it is the ratio of the load which would just crush the structure to the assumed load." It is further stated that "from 4 to 5 is a very common valve for wrought iron subject to tension or cross strain, from 4 to 6 for cast iron, 10 for wood and from 10 to 20 for stone." Non-technical journals frequently, and technical papers sometimes, state that "the structure is capable of sustaining a load 4 to 6 times as great as could ever be imposed upon it." It is probable that engineers, who use these expressions, would very much regret to see their statements tested by an application of 4 to 6 times the assumed load. Of course, no well-informed engineer really intends to convey this idea, although this is probably the one obtained by those who have given no special consideration to the matter. Understanding it in this way, directors, managers, highway commissioners, etc., feel justified in cutting down the estimates of the engineer, for they are led to believe that he has designed the structure to be 4 to 6 times stronger than is necessary; they reason, and correctly too, that a bridge that is sufficiently strong is as good as one that is 10 times stronger. This use of the term is probably the explanation of part of the indifference of highway commissioners in the matter of the strength of wagon road bridges. In addition to the impression made upon the public, this use of the term has had an injurious effect upon the engineer using it, for it is not difficult to believe that errors and defects in design and various approximations in the computations of strains have been allowed to go uncorrected owing to faith in an abundant factor of safety. This too when the value of this factor is arbitrarily assumed. It is thus made a cloak for a multitude of sins both of omission and commission.

This seeming extravagance of material does not really exist. The statement that a structure "is capable of sustaining 4 to 6 times the greatest load that will ever come upon it," rests upon the following assumptions: (1) that the moving load produces no greater strain than the same load at rest; (2) that the uniformly distributed load will produce the same strains as the actual loads upon the engine and car wheels; (3) that the weight of snow and ice, and the various effects of the wind have been correctly allowed for; (4) that the

joints are perfectly flexible; (5) that the strains pass axially through the several members; (6) that all members are equally elastic; (7) that the elongations and compressions are always proportional to the load producing them; (8) that the changes of form due to elasticity and change of temperature produce no additional strains; (9) that each piece returns to its former length after the stress is removed; (10) that the strength of full-sized specimens is directly proportional to that of small specimens; (11) that a force suddenly applied as in the actual bridge produces no greater stress than the same force slowly and steadily applied as in the testing machine; (12) that because a piece has borne a certain load it will again bear the same load, or even an infinite number of repetitions of that load, without loss of strength; (13) that the strength of a piece is independent of the range of strain to which it is subjected; (14) that the material is of the best and the workmanship perfect; and, if another reason were needed, we might add that in making the computations nothing was overlooked, nothing under-estimated, and no error made. None of the above assumptions is strictly true, and the errors involved in some of them are exceedingly serious. Bearing the uncertainties and errors of these assumptions in mind, it does not seem extravagant to state that the structure will bear only 1-6 to 1-4 of what it would stand if the above assumptions were strictly true.

However, the term "factor of safety," as defined above, when understood in its most favorable sense, is still objectionable; it assumes that the strain to which a piece can be repeatedly subjected without injury depends upon the ultimate strength of the material. If any member of a bridge is strained beyond its elastic limit, a permanent set is produced; this in turn produces a distortion of the figure of the bridge, or at least a change of the conditions upon which the strains were determined. A subsequent application of the load will therefore produce a very different effect than on its first application. All bridges are built on the assumption that having been loaded and the load removed, all parts will return to their former position. If such a term is used at all, it should express the ratio between the computed strain and the strain which the piece could bear without material alteration of length and strength, that is, it should express the relation between the computed strain and the elastic limit.

There is no definite relation between the elastic limit and the ultimate strength. Roughly, the elastic limit of any material is about half of its ultimate strength. Hence the supposed factor of safety of 4 to 6 as estimated in the usual way, is really reduced to less than 2 to 3 by this consideration alone.

The term "factor of safety" when used to signify the "ratio of the computed strains to the actual strains on a piece" does not give a correct measure of the security obtained. The strength of a piece depends upon the frequency with which it is strained and also whether it is subjected to the same constant stress, or is alternately

loaded and unloaded, or is subjected to alternate strains of tension and compression. Some of the members of a bridge receive their maximum strains more frequently than others, and the range of stress is different for the different pieces; consequently, if each has the same "factor of safety," estimated as above, the degree of security will be different for each piece. Under no circumstances can the use of the same ratio of computed to actual strains in a piece be justified for any structure subject to a variable load, even though it is frequently thus used. To secure uniform strength, it would be necessary to use a different "factor of safety" for each member.

It is reported that the term "factor of safety" is not used in Europe. Although still frequently employed in this country, it has been discarded by our best engineers. The more approved practice is to limit the strain that may come upon any member to a certain number of pounds per square inch, the amount of which depends upon the nature of the strain to be resisted, whether tension, compression, or shearing; upon the strain to which the given material may be subjected without damaging its recuperative powers; upon the frequency with which each piece is likely to receive its greatest strain; and upon the range of the stress upon the piece. In the most approved method of dimensioning the factor of safety, computed upon a rational basis, is not more than $\frac{25000}{15000}$ or $1\frac{2}{3}$, and it can be shown that there are several elements which certainly reduce this margin considerably.

It is doubtful if there are many railroad bridges in the country having an actual factor of safety of much more than one; the newer bridges doubtless have a factor of a little over one, but the older ones have a factor which is probably less than one. This does not mean that all, or even many, of our railroad bridges are unsafe; it means that when built, it was supposed the bridges would last forever, but that subsequent experience has demonstrated that they are comparatively short-lived. This deterioration in strength has been due mainly to increase of weight and speed of trains, and somewhat to lack of knowledge as to the effect of repeated strains on iron. Many such bridges have already been replaced with new ones designed in accordance with improved practice and to carry the heavier loads required by present or prospective traffic. Notwithstanding this state of affairs concerning railroad bridges, only about one in one hundred and fifty of the so-called bridge disasters is due to the failure of the material or workmanship of the bridge itself. This is due to the ability and skill with which the bridges were constructed and to the care in inspecting them, and, in view of facts revealed by inspection and by the failure of bridges, it must be confessed due partly to good luck. It will be fortunate, if these elements serve a like good purpose until all the old bridges are replaced with better ones.

There is one marked difference between bridge disasters on railroads and highways. There is no official record of highway bridge disasters. During the years 1873–85 the newspapers contained an

account of but two failures which were due to the failure of the material or construction of the bridge itself; and during the same time the newspapers have contained on an average the accounts of twenty failures of highway bridges, nearly all of which were doubtless due to the weakness of the bridge itself. The above data show that highway bridge failures are probably 130 times as frequent as the failures of railroad bridges.

WATER-WORKS.

The number of cities constructing or contemplating a public water service is rapidly increasing and from the natural conditions of things must for some time continue so to do. The present practice in most of the smaller places is to advertise for bids for constructing and maintaining a system of city water-works, the city to pay a stated rental per hydrant for a certain number of years, after which time it has the option to purchase the plant or make a new contract. The system is usually designed, constructed and operated by the contractor without any inspection or control by the city. This method has essentially the same objections that were urged against the ordinary method of erecting highway bridges.

The objections are, (1) the work is inadequately advertised; (2) the whole scheme is so indefinite and the prospect of any one getting a contract that a company will not make a bid without the expectation of a large profit; (3) the contractors propose the system in which they think there is the most money for themselves, regardless of whether it is best for the city; (4) the works are so cheaply constructed as to need frequent repairs at the inconvenience of the water users and at the risk to property in case of fire; (5) the works are not designed, nor the contract made, with reference to future enlargement, and hence subsequent modification to meet the growth of the city is needlessly expensive.

These evils would be obviated if a competent engineer were called to make a design, superintend the letting of the contract, and then inspect the works; the engineer would know how much the works should cost, and if the bids were thought too high, or if the proposed contract with city too unfavorable, the city could construct the works. A man competent to act in this capacity would demand a good salary, but would save many times that amount to the city; this salary is usually saved on the penny-wise-pound-foolish plan. That water-works are not substantially constructed, reference need only be made to the accounts in the papers recently of the failure of a number of water towers. Judging from the few the writer has seen, it is astonishing that such failures are not more numerous. Unquestionably many such structures are not reasonably safe. It is also certain that many cities are now paying exorbitantly for their water service.

It is highly probable that in the near future, the smaller cities will be repeating their present experience with water-works in secur-

ing a system of sewers. It would be far better that an engineer should study the questions of water supply and sewerage together, than that each should practically *happen* separately. The members of this society will be doing a good work, if they disseminate the truth concerning the best method of securing these two important public improvements.

STATE RAILROAD COMMISSION.

I come now to the question which in the beginning, I had hoped to make the principal subject of this address, but having consumed my allotment of time in the preface, I can only briefly look at one or two points under this head.

The constitution of 1870 provided for the appointment of a Railroad and Warehouse Commission which should have general supervision over the railroads and warehouses subject to such laws as the General Assembly might from time to time enact. The object uppermost in the mind of the people in demanding the commission, and the tenor of all the enactments of the legislature and also the principal acts of the commission, have been to arbitrate between the people and the railroads concerning rates.

The time has arrived when it is necessary to inquire what the first duty of such a commission is; whether it has not a higher duty than simply to hear the complaint of a farmer concerning the freight on a car load of lumber or of a manufacturer concerning the rates on corn-planters. In the development of the railroads of the country, the demand for the advantages of railroad transportation was so great that that the people willingly submitted to an inefficient, expensive, and even dangerous service; but in the natural course of events the people demanded better and cheaper service. In many cases competition or the selfish interests of the roads themselves prompted them to serve the people better at less cost; but in some cases it has been necessary to stimulate this action by legislation and the appointment of a commission to see that the contemplated improvements were made. In many of the states the Railroad Commission has been specially charged with the safety of the traveling public, but thus far, railroad legislation in the state of Illinois has concerned itself only about matters affecting the pocket-books of its citizens.

The state of Illinois has more miles of railroads than any other state in the union, is exceeded in total wealth by but two, and is exceeded in wealth per capita by probably only one or two, and yet we are content to allow a fearful loss of life and limb to go on year after year without any effort to prevent it. During the years 1883–6, which did not include any conspicuous disaster, the railroads of this state have averaged to injure nearly 1300 persons per year, of whom about one-third, or nearly 400, were killed outright. Last summer when we were unfortunate enough to have a single railroad disaster within our borders which, in point of numbers killed and also of

number injured, was exactly one-fifth as serious as the average record for the above four years, the people and even the whole country stood aghast, and demanded no end of improvements and precautions to prevent a similar occurrence; nevertheless there has been going on in our very midst a slaughter which each year amounts to five times the casualties of the Chatsworth horror, and we have simply sat still and done nothing.

To obtain a fair view of the question under discussion it must be borne in mind (1) that modern railway travel is marvellously safe. This fact is forcibly illustrated in the following statistics, which is frequently quoted, from the report of the Massachusetts Railroad Commission: "During the four years, 1875–8, only 1 passenger was killed from causes beyond his own control in Massachusetts, and only 20 injured. Yet during the year 1878 alone, excluding all cases of mere injury, of which no account was made, no less than 53 persons came to death in Boston alone from falling down-stairs and 37 more from falling out of windows; 7 were scalded to death. In the year 1874, 17 were killed by being run over by teams, and the pastime of coasting was carried on at the cost of 10 lives more. During the five years 1874–8 there were more persons murdered in the city of Boston alone than lost their lives as passengers through the negligence of all the railroad corporations in the whole state of Massachusetts during the nine years 1871–8, which included the Revere and Wollaston disasters, in which 50 people lost their lives. Neither are the comparative results here stated in any respect novel, or peculiar to Massachusetts; years ago it was officially announced in France that people were less safe in their own homes than when travelling on railroads; and, in support of this somewhat startling proposition, statistics were produced showing 14 cases of death of persons remaining at home and there falling over carpets, or in the case of females having their garments catch fire, to 10 deaths on the rail. Even the game of cricket counted eight victims to the railroads' ten."

(2) To the contrary, it is also well to bear in mind that, owing to the numberless chances of disaster, the operation of railways will always be attended with a seemingly considerable loss of life and limb. It is the part of true wisdom to recognize these two facts, and seek to determine and prevent the preventable catastrophes. Accidents will ever occur owing to the mistakes of employees or to the failure of some part of the equipment. All that can be hoped for is to reduce these to a minimum.

Notwithstanding wonderful improvements, the methods of railroad construction, of railroad equipment, and of railroad management are still very far from being perfect. Viewed in one light, each railroad disaster is a horrible object lesson showing the need of better equipment or of greater care in operation. All desirable improvements are not practicable; and in many respects the possibility of further improvements can be determined only by farther ex-

perience, and many undoubted improvements are beyond the financial ability of the companies. Railroad corpora tions are not bound to adopt every scheme and device that promises any increase of comfort or safety without regard to expense. On the other hand, the railroads are managed for the stockholders, who are generally more concerned about their dividends than about the safety of passengers or employees. The public cannot rightfully demand any improvement in equipment which will be unduly expensive for the road, or change in method of operation which would materially modify the method to which present employees are accustomed. Within these limits there is room for great improvements on present practice. These improvements should be demanded in the name of the public for the safety of passengers and employees, and the Railroad Commission should be empowered to see that these changes are made.

It has long been known that there were a number of points in which it was practicable for the railroads to modify their methods and improve their equipments so as to give greater safety to both passengers and employees. For example, no good reason can be assigned why the railroads should not be compelled to have a uniform code of signals, nor why the officers should not be compelled to so formulate the rules for the guidance of train men that they can be understood by the men who are to use them. Some striking examples could be cited under each of these heads, if time did but permit. Also railroads should not be permitted to employ a method of operation, which taxes employes, who are responsible for the safety of human life, beyond the limits of human endurance, as is now frequently done. Or again, it is well known that bridge accidents could be very much decreased by the employment of a simple and inexpensive device, the efficiency of which has been practically demonstrated many times; it is beyond comprehension why the roads have not all adopted some such device of their own notion for their own selfish ends. There are several other points on which it would have been entirely reasonable for the public to have demanded change and improvements years ago, as some of the states have already done.

The year 1887 will doubtless be a remarkable one in the history of development or railroads, as having demonstrated that it is entirely practicable to demand certain improvements in the equipment which will add greatly to the safety of both passengers and employees. One of the most prolific sources of injury to trainmen has been the hand brake and the link and pin coupler.

Unfortunately the writer has not the statistics at hand to determine the number of accidents in this state that are assignable to these two causes, but a valuable and interesting report on this phase of the question, by the Iowa commission, says that the hand brake and the link and pin coupler have caused the death of 469 and injured 1609 in the state of Iowa in the past 10 years. If these accicidents are proportional to the number of miles of road, then Illinois should have nearly five times as many as Iowa; and if they are pro-

portional to the traffic, then Illinois should have nearly eight times as many as Iowa. The actual number probably lies between these two. Assuming it to be the smaller number, then the number killed in Illinois by the hand brake and the link and pin coupler would be 234 per year, or more than three times the number killed in the Chatsworth horror; on the same basis the number of injuries would be 804 per year, or about four times the number of non-fatal injuries of the Chatsworth disaster. Is not this sufficient to warrant an attempt at a remedy?

The application of the power brake to freight train service has been proved beyond all controversy, by experiments conducted by the railroads themselves, to be not only eminently practicable but an economical feature. The railroads have decided through their Master Car Builders' association in favor of an improved coupler which is entirely harmless to the train men. Every objection to legislative action upon both of these indispensable safety appliances is now removed. The managers of the railroads themselves virtually come to the doors of our legislatures and ask for such laws as will enable them to demand of railway boards of directors and stock owners appropriations to enable them to fit up their cars with these safety appliances. It now rests with the people of this state to say whether it should be done or not.

Again, practical experiments last winter, and again this, have shown the possibility of doing away with the, in case of accident, deadly car-stove.

Enough has been said to show that the state may reasonably demand an advance in the equipment of our railroads to secure greater safety to its citizens. The members of this society should use their best effort to create a public sentiment that will secure these necessary reforms and improvements on the part of the railroads.

One other point in this connection and I am done. The relation of the state to the railroads is so complicated and the interests involved are so vast, that if the State Railroad Commission is to discharge its full duty both to the railroads and to the people, it must have the advantage of the abilities of an expert in railroad matters. The time is late and I will not even argue this self-evident proposition, but suggest that the members of this society, at the proper time, earnestly urge that a thoroughly competent engineer be appointed as one of the members of the State Board of Railroad and Warehouse Commissioners.

I thank you for your patient attention.

A RAILROAD CULVERT.

By EDWIN A. HILL, of Indianapolis.

In Putnam county, Indiana, between Raccoon and Russelville, the Indianapolis, Decatur and Springfield Railway crosses Nichol's Hollow on a three-story wooden trestle about 450 feet long and 67 feet high, with 18 bents spaced generally 25 feet centre to centre, the location being on a 3 degree curve.

Two years ago the question of renewal came up, and I thought you might be interested in the story of what we concluded to do in the premises and how we are now doing it.

The question presented itself in about this shape:

Plan 1—Estimated cost of a new wooden trestle		$6,000 00
Plan 2—Cost of 75,000 cu. yds. earth filling at 10c	$ 7,500 00	
" 465 cu. yds. culvert masonry at $7.00	3,255 00	
Total cost	$10,755 00	$10,755 00
Plan 3—Estimated cost of an iron trestle		$15,000 00

Assuming annual renewals to the wooden structure at a minimum of 10 per cent. on first cost, and capitalizing this annual charge at 6 per cent., gives a capital of $10,000.00, so that in this respect plans one and two compare closely with each other. Our management, however, were willing to incur considerable extra expense, if thereby they could secure good and substantial work, and were as willing to adopt as I to recommend the plan of an arch culvert and an earthwork embankment. Ten cents per yard for earth filling may seem pretty low to some of you, but we based our figures on past experience, of which I shall have more to say hereafter.

We had a spur track into a good sand stone quarry about two miles from the work, and we accepted an offer of dimension stone at $1.50 per yard loaded on the cars and measured in the work. I do not think the quarryman made much money on the contract, and presume he would want not less than $2.00 hereafter. The stone was of a gray color, and in some respects resembled the Berea Stone of Ohio. It quarries in blocks of large size without flaw or seam, is at first soft and easily worked but hardens by exposure. I had some large sized samples tested at our shops on our 200-ton driving wheel press and found its crushing strength to be quite uniform, averaging about 250 tons per square foot, rather lower than Berea Stone but still strong enough for the purpose, especially considering its uniformity of strength. Some of our bridge abutments had been built with this stone in 1878, and an inspection of them was favorable to its further use. As the quarry is quite accessible from central Illi-

nois I have for the benefit of the members of this society appended a table giving the results of our tests. (See Appendix.)

By what rule should we determine the area of waterway in culvert construction? Formulæ there are indeed, but the difficulty in applying them has been well put by a writer who asks what difference there is between guessing at the proper proportions in the first place, and guessing at the value of the constants which we must insert in the various formulæ. Probably the best course to pursue is to estimate approximately the drainage area and apply all known formulæ, and then to inspect the country and particularly any bridges that exist further up the stream looking for the various evidences of high water, and finally to make a judicious guess at the proper area, taking the side of safety in all cases of doubt. I do not mean to decry the use of the formulæ, but their abuse. They should be used cautiously, and be regarded rather as aids and checks than as final authority. In this case I followed the stream to its source and approximately determined its drainage area, which I was enabled to do with sufficient accuracy in a single afternoon by locating various controlling points by inquiry as to the section, quarter-section, &c., in which they were situated, and $2\frac{1}{2}$ square miles or 1,600 acres was a liberal estimate of the area drained.

And now a few words as to formulæ for area of waterway.

The formula of Col. E. T. D. Myers, as quoted in Cleeman's Railroad Engineers' Practice, is

$$\textit{Area of waterway in square ft.} = C\sqrt{\textit{Drainage Area in Acres,}}$$

with C taken at 1.6 in hilly compact ground, at 1 in comparatively flat ground, and as high as 4 in mountainous country. The waterway for 1600 acres, determined as above, will vary from 40 to 160 square feet, depending on the values assigned to C. This formula is discussed editorially in the Railroad Gazette, (article reprinted in Engineering News for Sept. 18th, 1886) and for large drainage areas probably gives excessive results and should be used with caution. This editorial deserves careful reading from all interested in the subject; in closing the writer recommends the following formula: "Guess at the proper size and then double the result for safety."

Some of the formulæ give the number of cubic feet of water per second arriving at mouth of culvert or sewer, leaving us to proportion the structure accordingly. The various manufacturers of culvert pipe in their trade catalogues usually assume a maximum delivery of 300 gallons per minute per acre of drainage area, corresponding to a rainfall of one inch per hour with 75 per cent. of same reaching the culvert, which for 1600 acres would give a maximum discharge of 972 cubic feet per second. While one inch of rainfall per hour has often been exceeded, yet for large drainage areas the percentage reaching the culvert is certainly much less than here assumed, though for the comparatively small areas drained by culvert pipe the formulæ may not be excessively in error.

Trautwine, so frequently our last resort, (Edition of 1885, page

278) gives the following formula for sewers and culverts, which, however, I presume is more particularly designed for sewers and city drainage than for culverts and country districts:

$$\left.\begin{array}{l}\textit{Cub. ft. per second per}\\ \textit{acre reaching culvert}\end{array}\right\} = C \times \left\{\begin{array}{l}\textit{inches of rain}\\ \textit{per hour}\end{array}\right\} \times \sqrt[4]{\frac{\textit{Average slope of ground in feet per 100.}}{\textit{Number of acres drained.}}}$$

with C taken at 0.75 for paved streets, at 0.625 for suburbs with gardens, lawns and macadamized streets, and at 0.31 for ordinary cases and assuming the heaviest rain fall at from $1\frac{3}{4}$ to $2\frac{3}{4}$ inches per hour. Using 0.3 for C and 1600 acres of drainage area, this formula indicates about 150 cubic feet of water per second delivered at the culvert for each hourly inch of assumed rainfall.

The original plan called for a semicircular arch about 200 feet long, 6 foot span, area of waterway about 32 square feet, on a grade of 15 inches per 100 feet, which by Trautwine's formulæ and tables (Edition 1885, pages 274 and 276) indicates a carrying capacity of 442 cubic feet per second or about 13.8 cubic feet per second per square foot of area of opening when flowing full.

When built the opening was increased to about 35 square feet of area for reasons explained hereafter, corresponding to a maximum capacity of about 485 cubic feet per second and sufficient for a rainfall of $3\frac{1}{4}$ inches per hour by Trautwine's formula, C being taken equal to 0.3, but for a rainfall of only $1\frac{5}{8}$ inches by the formula of the culvert pipe makers (assuming their data to apply to such large areas) and corresponding to the assumption in Myers' formula of $C=\frac{7}{8}$, which is lower than any value advised by him.

Sixteen hundred acres, however, was probably in excess, and several years observation by the road department had failed to discover more than from 12 to 15 cubic feet per second passing in times of highest water, and as the structure could probably run under a considerable head for a reasonable time without injury, I saw no reason for adopting larger dimensions.

I would suggest as a practical method of culvert proportioning that observations be made at the given locality to determine for a known amount of rain-fall per hour the corresponding depth of water at its highest stage. Observations of a few storms would probably show a nearly uniform ratio existing between the volume of water passing and the inches of rain-fall per hour. We could then assume a maximum fall of say three inches per hour and compute our required culvert capacity by simple proportion. No elaborate instruments would be required and the observations could be made by section foremen on constructed line, and by members of the engineer corps on new construction. I think in this way we would eliminate much of the uncertainty which follows from the use of the various formulæ and for my own part I intend to try the method on my next culvert.

The first plan called for a pavement or flagging of large flat stones one foot thick, on which the side walls were started three feet

high 3 feet 3 inches thick at base and battered 2 inches per foot at back, from which a semicircular arch of 3 foot rise and 6-foot span was sprung with an arch ring of 18 inches depth and backing carried up two feet above the spring line. Cut stone work with dressed joints and beds was specified throughout, ranged work outside and broken courses within. The wing walls were regularly stepped down in courses one foot thick and were rounded into the side walls. This latter feature was accomplished by causing the face of the wing walls (battered $1\frac{1}{2}$ inches per foot) to intersect the side walls at the spring line of the arch. This would naturally cause the battered face of the wing to project in front of the culvert opening, but by cutting away this projecting portion so as to round the ring walls into the side walls, the junction between wings and sides was effected without leaving any angle to catch floating timber and other obstructions. Moreover such a rounded or funnel-shaped entrance for the water adds materially to the capacity of the culvert when running under a head.

I think this method of construction has only to be understood to be widely adopted. Eighteen inches is a rather unusual depth for an arch ring of six-foot span, but was adopted because of the height of bank (67 feet from bed of brook), the somewhat low crushing values found for the stone. and because the extra depth added but little to cost compared with the extra strength thereby obtained. The proportions of the culvert were fixed approximately by Trautwine's rules, and those finally adopted were checked by comparison with the practice of the Pennsylvania and West Shore railroads for similar spans and found to correspond closely; lines of pressures were then drawn for the arch both unloaded and with full load of earth and train, assuming weight of earth at 130 pounds per cubic foot, and train load, distributed by crossties eight feet long, as equivalent to three extra feet of filling corresponding to 3360 pounds per lineal foot of train. I here made use of the graphic methods detailed in Prof. Cain's two works on arches, Van Nostrand's Science Series, Nos. 12 and 42. Those interested in the subject are referred to them for full information.

From some excavations made in 1886 I inferred we should have a stratum of tough blue clay of unknown thickness on which to start our foundation course. I suggested a series of test borings along the selected site, but there were no tools at hand for the work, and the company thought it an unnecessary expense.

Construction work was finally postponed until last June when we commenced excavating on the plan already outlined. The railroad runs approximately east and west, and the brook north and south. I located the arch in the space between the trestle bents just east of that occupied by the brook so as to straighten the channel. Here we had an undisturbed stratum of earth with a surface six or seven feet above the bed of the brook, giving supporting side walls of compacted earth for about 130 feet along the lower end of the

arch, the plan being to begin at lower end with a drainage ditch leading south into the brook below, and so advance north with the work, thus avoiding trouble with water by draining through the completed culvert.

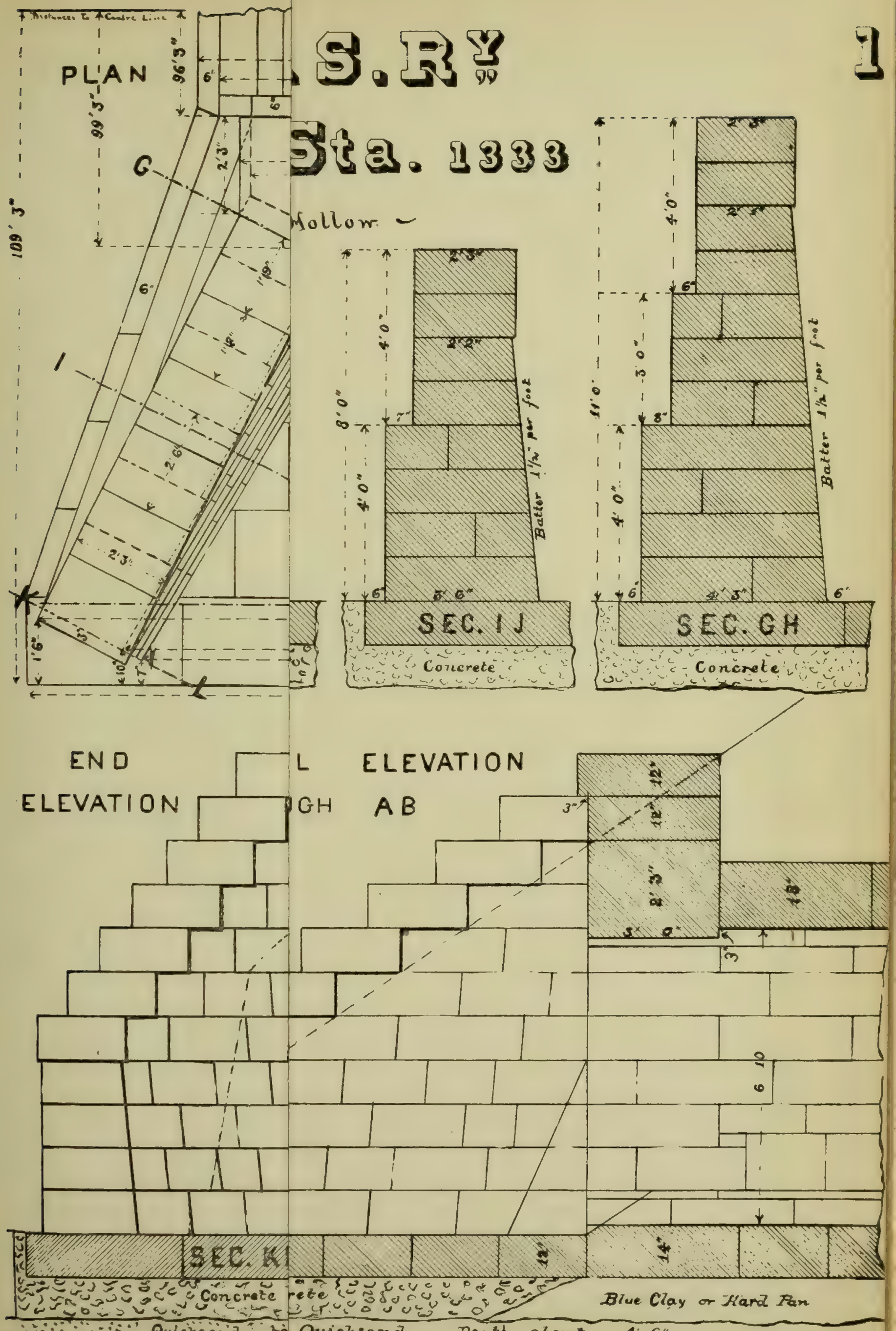
The location called for about 1 foot of excavation in the blue clay, but while excavating for the wings of the south portal, and when only 8 inches of clay had been removed, we came upon a bed of bad quicksand between 4 and 5 feet deep, apparently extending northward under the entire work. This lead to a radical change in plan, an invert was substituted for the flagging or paving, and the entire structure was raised one foot in order to interpose the undisturbed layer of blue clay between the quicksand and bottom of invert. Where this clay had been removed and the quicksand partly exposed, we filled in carefully with spalls, on which foundation we spread about one foot of concrete, and upon this laid our invert and foundation courses.

The invert was carried in from the south portal with carefully cut stone work for about 40 feet, but a series of test borings proved that going north along centre line of culvert the clay increased and the quicksand decreased in thickness. I therefore for the remainder of the distance laid the invert in rubble, well grouted with Alsen Portland Cement mortar, using 4 of sand to 1 of cement, until the grout came to within about 4 inches of the upper surface of invert, and then finishing with a grout of 2 sand to 1 of cement where exposed to running water.

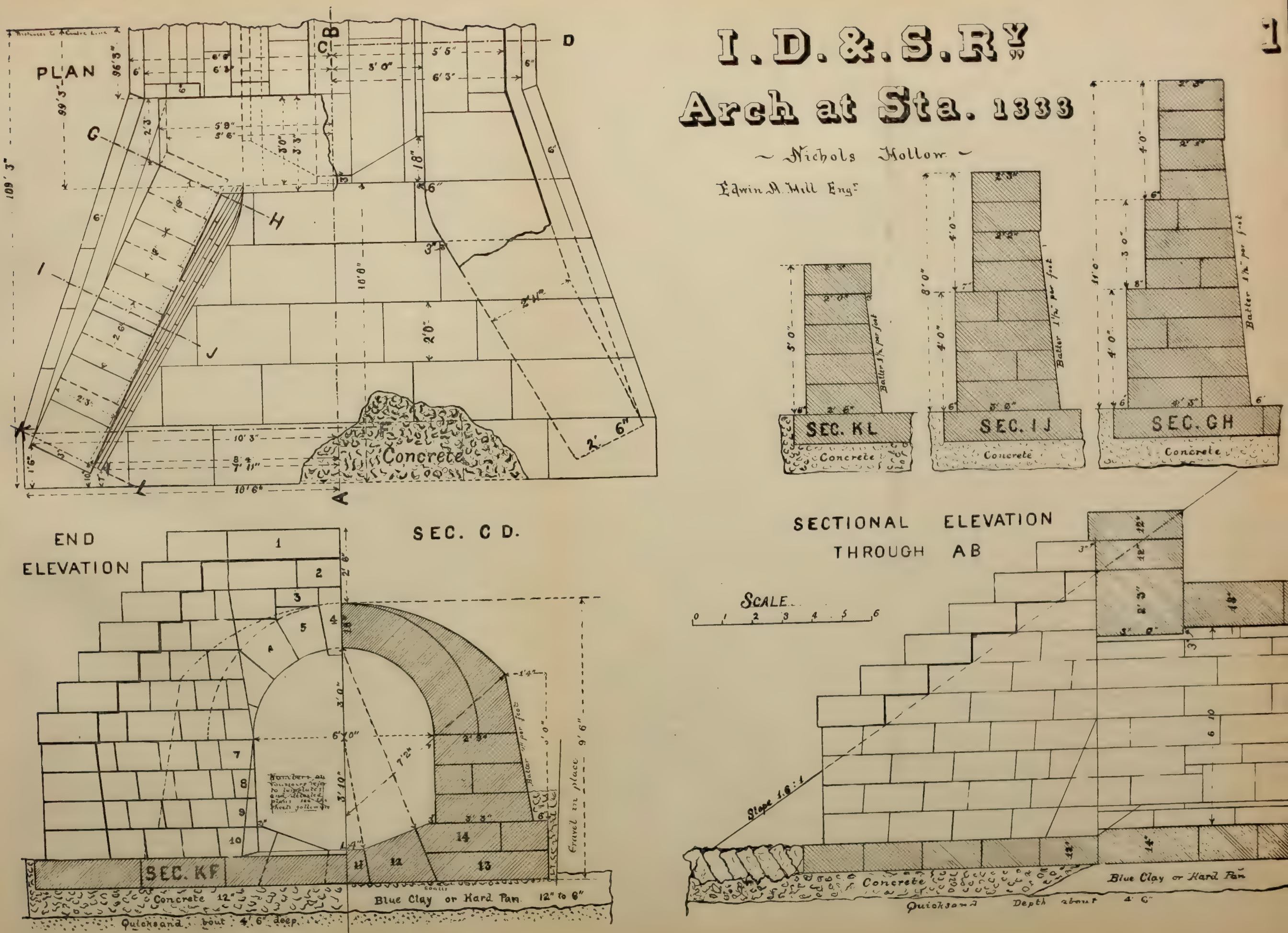
An invert as a bottom for a culvert has this advantage among others of concentrating the flow at low stages of water and so tends to keep the water-way free from obstruction. Our improvised augur for making test holes was simple but effective. It was merely one of the long 8-foot augurs, 2 inches diameter, with the iron stem bent into the form of a brace, which had been used up and discarded by our gang of bridge carpenters, and with it we easily penetrated 5 or 6 feet.

I will not describe the modified arch in detail, as the plans speak for themselves. It is in the main the original plan modified by the invert and so has a little more area of water-way than at first intended. It is located on a pretty steep grade, $1\frac{1}{4}$ feet per 100 (the average grade of brook).

To build cheaply material must be handled cheaply. We had accumulated from bridge repairs a number of 20-foot sticks of timber, size 6x15; with these we built at east end of trestle and level with the track a platform, and from it a chute running down the bank on which to unload and slide the stone. Six timbers laid flatways side by side with two timbers edgeways for sides gave us a chute 7 feet 6 inches wide supported on cross ties of same material spaced 10 feet between centres, each timber drift-bolted to each tie and bolted laterally through all with inch bolts 8 feet 6 inches long. Five lengths of 20 feet each gave us a total length of 100 feet and fall of



S. R'y
Sta. 1333
PLAN
Distances to Centre Line
Hollow
SEC. I J
SEC. G H
Concrete
Batter 1½" per foot
END
ELEVATION
L ELEVATION
GH AB
SEC. K
Blue Clay or Hard Pan
Quicksand
Depth about 4' 6"



I. D. & S. Ry
Arch at Sta. 1333
~ Nichols Hollow ~
Edwin A. Hill Engr
PLAN
END ELEVATION
SEC. C D.
SECTIONAL ELEVATION THROUGH AB
SEC. KL
SEC. IJ
SEC. GH
SEC. KF
Concrete
Batter 1½" per foot
SCALE
0 1 2 3 4 5 6
Slope 1.6 : 1
Blue Clay or Hard Pan
Quicksand Depth about 4' 6"
Quicksand about 4' 6" deep
Concrete 12"
12" to 6"
Gravel in place
Numbers on voussoirs refer to templates; and detailed plans see the sheets following

60 feet, being at an angle of about 37° or slope of 1¼ to 1. This chute carried over 600 tons of stone—all that was used on the work, mostly in blocks weighing from 1 to 3 tons, without needing repairs and with no very great wear. Stones were unloaded from the local freight trains at the top of the chute, handled there by two men with bars and gas pipe rollers and allowed to slide down by their own weight, and received at lower end in a bank of sand and old railroad ties, in order to break the force of fall. There they were swung by a small derrick clear of the following stone and over on to a push car and were at once run off by hand on a temporary track to the work, where they were placed for cutting, and subsequently swung into place on the wall by another derrick. The derricks we had on hand. The cost of labor for setting them up, building chute and a shed for use of cutters in rainy weather was only $14.63. Tracklaying, $7.70. Roofing of shed was of fence material afterwards used in fence construction. Track material subsequently went into side track construction, and the other material used was condemned bridge stuff. This expenditure of $22.03 paid for itself many times before the completion of the work, and did much to keep down the total cost.

At intervals of 40 feet or so 4-inch square stakes were driven on centre line of culvert with top to grade of upper surface of key of invert. Centres were fixed by driving nails, and a mason's line was stretched from nail to nail. The key of invert was then laid in line and grade by this line; and as the work advanced a 6-foot tram or template placed on the invert with central notch over the centre line and properly leveled gave at once the outline of invert and location of side walls. The tram was used, however, in the cut work only, but line and grade was given throughout as above stated. The construction of the arch centres calls for no comment further than that they were supported from the floor of water-way instead of from a projection at the spring line as is usually the case.

One trench, 15 feet wide, was carried through a clear space of 24 feet between trestle bents at a depth of 6 feet below surface, trains running at a height of 66 feet overhead. We here used for sheet piling (to keep earth from caving under sills of trestle,) plank 1¼x6 inches, driven 18 feet at bottom into a tough clay and braced at top by old bridge timbers, dimensions 7x13 inches, placed at the plumb and batter posts of the trestle. When the excavation progressed north so as to cut through into the channel of the brook near its westward deflection we built a temporary dam, turning the water still farther westward and completely out of our way, tearing away the dam on completion of the work. Old bridge timbers and the natural soil were our materials for dam construction.

Excavation for masonry was begun June 15, 1887, and the culvert was finished last October. Filling by steam shovel and unloading plow began October 10, 1887. The culvert proper contained 613

cubic yards of masonry and $24\frac{3}{4}$ yards of concrete. Masonry cost \$4.09 per yard for labor and \$2.50 for material or a total of \$6.57 per yard. Concrete (for labor only) cost \$1.78 per yard. Stone quarrying was by contract, all other work by days' wages. I append an itemized statement of cost (appendix B) to which I must refer you for further data, and I also append copies of the quarry contract and specifications (appendix A). Some favor was shown the quarryman and the specifications were not followed as rigidly as would have been the case in contract work, a little latitude being allowed the foreman, particularly in the dressing of stone, but the general character of the work was in no material respect lowered or impaired.

The work was carefully pointed inside and out with cement mortar and the extrados of arch likewise received a good coating. We intended to use Black Diamond Brand Louisville Cement, but a car-load lot obtained from a local dealer proved defective and led to the adoption of Alsen Portland Cement throughout. While waiting for an invoice of Alsen, however, we were forced to use forty barrels of English Burham Portland and also twenty barrels of Anchor Brand, Louisville. With Portland Cement we used four of sand to one of cement for interior work, and two of sand and one of cement where exposed to weather or water. Louisville Cement we used two to one throughout. In special places we used as high as one to one of Portland. The arch ring was set entirely in Portland mixed usually two of sand to one of cement.

For cement testing our people objected to paying from \$75 to \$150 for a testing machine, and we built one at our shops at an expense of \$15 that answered well enough, its essential elements being an ordinary spring balance with rotary index hand, weighing by ounces up to 30 pounds or 480 ounces, and a lever connection by which each ounce on scale represented one pound stress on the briquette of cement. All unregistered weight was taken off the briquette by a counter weight and cord carried over a pulley, and the briquettes were ruptured by a lever and the pressure registered by a telltale index hand.

I am convinced that the slight errors of such a machine are far within the ordinary variations caused by differences in the ramming of the cement and that it is as good for all practical purposes as any of the high-priced machines.

I have written a long paper but feel I ought not to close without saying something about steam shovel work. With good management a shovel will accomplish much at a minimum cost, while with poor management the little that is done will be at a cost so unreasonably large as to create a prejudice against the shovel often difficult to overcome. From what I have seen of shovel work I should invariably have the shovel, plow, engine and flat cars overhauled and put in thorough repair before beginning a job of work. Delays will be many even when this is done, and each delay means an expensive plant and a gang of men idle and a heavy expense. It

is important also to strike a proper balance between the work of the shovel crew and train crew respectively, so that neither will have to lose time while waiting for the other. As a rule the length of haul is a fixed quantity, and the maximum economy will occur when the shovel has trains always ready when it is ready to work, and the trains find the shovel always ready to load on their arrival. In practice we should approximate as closely to this state of affairs as possible. We should aim to move the shovel while trains are unloading, and to accomplish this it will sometimes be advisable, within moderate limits, to fix the number of cars loaded per train by the height of bank in which shovel is working. With a short haul and a low bank we may put in as many flats as the shovel can load in one shift, say 15 to 25, depending on hauling capacity of engine over the given grades, &c., and then occupy the time the train is away in shifting for next load. With a longer haul and higher bank a few extra flats could be left for the shovel to work on after shifting and before arrival of train; and with a still longer haul and lighter bank, two trains could be used, one loading at the shovel while the other unloads at the work.

It is well to have a competent and energetic man on the ground in charge, paying him a generous compensation and looking to him to get the maximum of work possible out of the plant and crews. Our foreman is an old freight conductor who acts as engineer at the shovel and conductor on the train, and is in command of both train and shovel crews, receiving $125 per month, and is emphatically the right man in the right place, and a valuable man for the company. Even with the best of crews and foremen, a close daily supervision is indispensable in order to keep the plant up to its full duty.

We began filling in our trestle October 10th, 1887, and stopped for the winter December 2d, 1887. Our shovel is of the Otis type, built by John Souther & Co.; cuts about 24 feet wide to a depth of 4 feet below the track. We have been working in a bank about 15 feet high and loading twelve flats for a train load. Shifting shovel occupies about five minutes. Our haul averages about 4000 feet. Under ordinary circumstances it takes about 15 minutes to handle the cable and plow off, but by an ingenious contrivance for loading the cable, devised by Mr. B. Fagan, our foreman of bridge repairs, we have reduced the total time of unloading to about 5 or 6 minutes.

Our usual complement of men consists of a foreman in charge of the work, who acts as train conductor and engineer of shovel, at $125 per month; a cranesman at $2.00 to $2.50 per day; a foreman for shovel at $1.50 per day; four pitmen who clean after the shovel, assist in moving it, and in clearing the tracks and handling the cable in plowing off, each at $1.25 per day; and one watchman at $1.00 per day.

We have thus far handled 2,612 car-loads or about 21,000 cu. yds. of earth filling at a cost for labor, repairs and supplies of 59¾ cents per car, or 7½ cents per cubic yard. Fuller details are given

in Appendix D, which table is a record of about 22,000 car-loads of earth handled by our shovel during the last three years. We have loaded as many as 124 cars per day, and have averaged 68 per day summer and winter. Our average expense for loading merely, which includes wages of shovel crew, repairs to plant and about one-third of the supplies, is about 40 cents per car load or about 5 cents per cubic yard. Total expense for loading, transporting about 1 mile, unloading with plow and distributing on bank when necessary, is about 57 cents per car-load or 8 cents per yard, which includes all possible expense except interest on cost of plant. On our third job under favorable conditions we have a record of 47½ cents per car-load or about 6 cents per yard, which was a job of trestle filling at the Sangamon River near Decatur. Other data will be found in the table.

The report of the Roadmasters' Association for 1885 contains some steam shovel data which it may be of interest to compare with the above figures:

1. The Baltimore & Ohio road, loading with steam shovel and unloading with side dump cars, claims to haul 5 to 25 miles, including train service and supplies, at 8.1 cents per yard.

2. The Michigan Central road presents a record of 20,000 car-loads of gravel, banks 7 to 9 feet high, at a cost for loading of 4½ cents per yard, including coal, oil, waste, labor and repairs. Cost per yard for hauling 30 miles, 735 yards per day, two trains and crews, 4 cents per yard for labor only.

3. The Ohio Central road with steam shovel and ballast unloader and train of 30 to 35 cars, claims an average cost for hauls of various lengths of $1.00 per car or say 12 cents per yard.

4. The N. Y., P. & O. R'y gives 7 cents per yard, at the rate of 8 yards per car, as cost of loading by steam shovel.

5. The Central Iowa road presented as their record of 4,803 car-loads handled the following figures:

Loading	.38	cents	per car,	or	4.75	cents per yard.
Unloading	.15	"	"	"	1.9	" "
Engine service	.25	"	"	"	3.1	" "
Total cost	.78	cents	per car,	or	9.75	cents per yard.

Our figures it will be seen do not suffer by comparison. Much of the credit for them belongs to our Roadmaster, Mr. A. J. Diddle, who has charge of our steam shovel work, and to whom I am indebted for much advice and counsel in connection with the culvert work herein described,—an engineer neither by title nor profession, but one of those men occasionally met with who through long experience and by practical attainments, have become far more worthy of the title than many who are acknowledged authorities in the profession.

APPENDIX C.

Table of tests of stone at I., D. and S. Ry. shops made on their 200 ton driving-wheel press. The direction of pressure was perpendicular to the natural bed:

No. of Test.	Dimensions in inches.			Area of Cross Section.	Cracking Pressure		Crushing Pressure.		Manner of Equalizing Pressure.
	Length.	Breadth.	Depth.		Tons.	Tons per sq. foot.	Tons.	Tons per sq. foot.	
	Raccoon Sandstone, Raccoon, Ind., on I., D. and S. Ry.								
1	7¼	3⅝	2⅞	26.28	18.5	101	51.5	287	
2	7¼	3⅝	2⅞	26.28	32.5	178	48.0	263	
3	10½	2⅝	2⅛	27.56	27.0	141	44.0	230	
4	10½	2⅝	2⅛	27.56	13.0	68	44.0	230	Sheet lead
	Average					119		251	
	Bedford Oolitic Sandstone, Bedford, Ind., on L., N. A. and C. Ry.								
1	7 5-16	3 11-16	2⅞	26.97	22	118	65	347	Lead.
2	7 5-16	3 11-16	2⅞	26.97	12	64	60	320	Leather.
3	10⅝	2 11-16	2 3-16	28.9	23	115	65	324	Lead.
4	10⅝	2 11-16	2 3-16	28.9	53	264	67	332	Leather.
	Average					140		331	
	Greensburg Limestone, Greensburg, Ind., on C., I. St. L. & C. Ry.								
1	6⅜	3 11-16	2⅞	23.5	50	306	110	673	Leather.
2	10½	2 7-16	2⅛	25.66	not	taken	87	487	Lead.
3	4	2	2	8.00	8	144	40	720	Lead.
4	2 1-16	2 1-16	2 1-16	4.25	25	847	33	1118	Leather.
	Average					432		834	

APPENDIX A.

EXTRACT FROM SPECIFICATIONS.

For the erection by company's workmen of an arch culvert at Nichol's Hollow Trestle, at Station 1333 of the I., D. and S. Ry. centre line, as per plans by Edwin A. Hill, Eng'r.

1. *Conduct of Work.*—The work to be under the direction of the master mason, subject to the supervision of the Engineer.

* * * * * * * * * * * *

8. *Manner of Laying Stone.*—Each stone, before being laid, to be carefully cleaned and moistened, and then laid level on its natural bed, in a full bed of cement mortar so as to make ¾-inch joints, the mortar being well forced into the vertical joints with the trowel, and each stone settled into place by blows, either from a wooden maul or from ordinary stone hammers upon suitable blocks of wood interposed to temper the force of the blows. Heavy stone to be lowered into place by crane or derrick without shock to the masonry, and any stone whose bond or set is in any manner disturbed to be taken up and reset. All masonry in face of walls to be well pointed with cement mortar.

9. *Ashlar Masonry.*—Will be used in the faces of end, wing and side walls. Each stone to retain its natural rock face as it comes from the quarry, but to have its edges pitched to a straight line, and all projections exceeding three inches to be roughly scabbled down. In general, each stone to be well squared, with beds well dressed with a tooth chisel (except that stones with a good natural bed may be used in the side walls) and with vertical joints so dressed for at least six inches back from the face, and as much more as the stone will work. Ashlars to have at least one-quarter more width of bed than depth of course, and a length of from two to four times their depth. To be laid at the rate of one header to two stretchers, so disposed as to make efficient bond, with joints well broken in the adjoining courses, the headers to hold the same size in the heart of the wall that they show on the face, and generally to be of like dimensions with the stretchers.

10. *Backing.*—The backing to go up with the facing but not in advance of it. In general the stones for the heart of the wall will be of similar dimensions to those used in the face, and the foregoing specifications as to Ashlar masonry will here apply, except that the vertical joints will be merely scabbled down to as close a joint as can in that way be readily obtained; any remaining spaces to be filled with small sound stones or spalls, and grouting used if deemed necessary by the master mason. The master mason will in general be allowed some latitude in order to enable him the better to work out the dimensions of the plan and secure a more efficient bond, but stones are always to be so laid as to properly break joints and thoroughly bond the work in all directions, and the use of small stones is to be avoided as much as possible.

11. *Arch Masonry* will in general conform to the foregoing specifications for Ashlar Masonry, so far as the same apply, and are not inconsistent with the following: The beds and joints of all voussoirs to be carefully dressed throughout with the tooth chisel, so as to be true and without slack or want and to lay with a $\frac{3}{8}$-inch joint. Their bed to truly conform to the radii of the arch, with end joints vertical, and each stone to be so cut as to set smoothly on the centering with the beds at their proper inclination. Each stone to extend through the whole thickness of the arch ring so as to bond with the backing. No voussoir to have a thickness, measured on the intrados perpendicular to the bed, of more than twelve or less than eight inches; no bed to be more than three feet in length.

12. *End Walls and Wing Walls.* The stones for the end walls to be rock faced, and of the dimensions and arranged as shown on the plan, but in other respects to conform to the foregoing specifications for Ashlar Masonry; wing walls to be tooled off smoothly where they round into the side walls as shown on the plan.

13. *Side Walls* to be of broken-coursed Ashlar Masonry in conformity with the foregoing specifications. Generally no course to exceed 24 inches in depth, not more than half of the stones to be less

than 18 inches deep, and none of them, except closers, less than 12 inches deep.

14. *Coping, &c.* Coping of end walls, and steps of wing walls, to be dimension stones, of the sizes and arranged as shown on the plan. To be dressed throughout with the tooth chisel on beds, joints, and faces, with clean straight arrises around the faces.

15. *Curb.* The outer edge of the apron to be protected by a curb of long stones 12 inches wide and 3 feet deep, set edgewise in a trench, and packed on each side with concrete.

16. *Invert* to be of two kinds or classes—(1) cut stone work which is to conform to the specifications for Arch Masonry, with each stone properly laid in Portland cement mortar; (2) rubble work, the stones for which are to be roughly shaped with a stone hammer, laid dry in lengths of four or five feet and then thoroughly grouted with grout of Portland cement.

17. *Specifications* for unhewn stone for culvert at Nichols Hollow, I., D. & S. R'y: All stone to be quarried without blasting from the lower beds of the Raccoon Quarry; to be free from seams, quarry scales, and earthly matter; perfectly sound so as to ring under the hammer; and to contain nothing tending to cause them to soften or scale under the action of the elements. All stone for the same class of work to be as nearly as possible of uniform color and appearance, and generally to be selected stone, as hard, strong and durable as the quarry can produce. The contractor is to deliver from time to time loaded on the cars at the quarry, at three days' notice, unhewn stone, in the rough as quarried, in blocks of size and shape sufficient to readily cut to the dimensions which will from time to time be furnished by the master mason as the work progresses, and any expense incurred by the Receiver, caused by delay in furnishing said blocks of stone after due notice given, is to be deducted from the amount due on any estimate, or recovered by process of law, as said Receiver may elect. The Engineer of said Receiver is on or before the fifteenth day of each month to certify to an estimate of the number of cubic yards of masonry laid during the preceding month, and is thereupon to approve of a voucher in favor of said contractor in payment for sixty (60) per cent. of the stone so measured in the work and furnished during the preceding month at the rate of one dollar and fifty cents ($1.50) per cubic yard. Payment for the remaining forty (40) per cent. being deferred until the completion of the work, when a final estimate is to be made of the entire cubic contents of the finished culvert, and if these specifications shall have been fully complied with by said contractor, he shall then receive an approved voucher as above for the amount of such final estimate, less the sum of the vouchers previously approved for him on monthly estimates.

APPENDIX B.

COST OF ARCH CULVERT.

613 CUBIC YARDS OF MASONRY.

Items.		*Total Cost.*	*Cost per cu. yd.*
Cutters and helpers, cutting stone	$1370 48		$2 24
Templates, straight-edges, bevels, &c	11 00		01
Repairs of cutters' tools	52 39		09
Water boy	11 75		02
Total cutting	$1445 62	$1445 62	$2 36
Masons, laying stone	$ 384 87		$ 63
Helpers to masons	453 66		74
Mortar mixer	121 72		20
Water boy	11 75		02
Track laying	7 70		01
Derrick, stone chute, &c	14 63		02
Arch centres, built and erected	37 65		06
Total laying	$1031 98	$1031 98	$1 68
Pointing		$ 30 00	$ 05
Total labor		$2507 60	$4 09
613 yards stone @ $1.50		$ 919 50	$1 50
100 bbls. Alsen Portland Cement (German)	$ 315 00		
30 " " " "	97 50		
40 " Burham " " (English)	130 00		
20 " Louisville " (Anchor Brand)	20 00		
10 " " " (Bl'k Diamond)	8 75		
Total cement	$ 571 25	$ 571 25	$ 94
7 car-loads sand @ $5.50		38 50	06
Total material		$1529 25	$2 50
Grand total		4036 85	6 59
Concrete	$ 43 75		
Excavations for foundations and drainage	260 77		
Sheet piling	19 69		
Timber for drain trough	2 59		
Extra allowance on sheeting stone	20 00		
Total	$ 346 80	$ 346 80	
Grand total		$4383 65	

MISCELLANEOUS DATA.

CEMENT.—125 lbs. per yard of masonry, or 2 2 5 yards masonry per bbl. of Louisville of 300 lbs., and 3 1-5 yards per bbl. of Portland of 400 lbs.

SCALE OF WAGES.—Foreman, $3.50 per day of 10 hours; cutters, $3.00; carpenters, $2.50; mortar mixer, $1.50; laborers, $1.25; water boy, 50 cents.

CARS loaded with about 12 yards of stone.

APPENDIX D.

Steam shovel work, I. D. and S. Ry. Supervision of A. J. Diddle, Roadmaster:

DATA.	Sangamon River Trestle.	Montezuma Gravel Pit.	Sangamon River Trestle.	Guion Trestle.	Nichol's Hollow Trestle.
	1885	1886	1886	1887	1887
First car loaded	Oct. 26	Jan.19	Sept. 3	May28	Oct. 10
Last car unloaded	Dec.18	July24	Oct. 21	Sep.12	Nov.30
Total number of days	54	186	48	108	51
Number of working days	46	115	38	85	40
Days idle in addition to Sundays	0	45	3	7	4
Nature of material handled	light clay	Gravel	light clay	light clay	light clay
Average height of bank	10 ft.	12 ft.	10 ft.	10 ft.	12 ft.
Total number of cars loaded	2899	8631	2771	5254	2528
Greatest number of cars loaded per day	94	124	90	80	75
Least number of cars loaded per day	22	16	50	30	15
Average number of cars loaded per day	63	75	73	61.8	63.2
Average length of haul	1 mile	9miles	1 mile	2miles	¾mile
Grade—Shovel to Dump—feet per 100	—1.00	varying	—1.00	—1.00	—1.00
Tons of coal used—shovel and engines	141	853	99	170	65
Number of car loads per ton of coal	20.5	10	28	30.9	38.9

COST OF WORK PER CAR-LOAD.

	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Foreman at $ 25.00 per month	8.86	9.67	8.00	9.01	9.88
Cranesman at $2 00 to $2.50 per day	5.35	5.62	4.80	3.54	5.57
Fireman (shovel) at $1.50 per day	2.88	3.37	2.87	2.90	3.27
Laborers (4) at $1.25 per day	7.86	9.92	8.77	9.80	9.80
Watchman at $1.00 per day	2.07	1.96	1.88	2.50	2.25
Total shovel crew	27.02	30.54	26.32	27.75	30.77
Engineer and fireman (engine)	12.00	14.50	7.44	11.00	13.10
Trainmen (conductor, $2.50; brakemen, $1.50)	5.97	14.60	5.74	5.25	5.77
Total train crew	17.97	29.10	13.18	16.25	18.87
Helpers distributing earth @ $1.10		1.12			2.72
Helpers loosening frozen ground ahead of shovel, $1.10		0.62			
Section men (track work) at $1.10	0.81	1.88	1.38	1.45	2.08
Bridge carpenters (repairs to plant), $2.50	0.15	1.58	0.16	1.04	
Section men (repairs to plant) $1.10		0.62			
Shop bills (repairs to plant)	1.69	10.90	1.27	10.60	1.67
Total repairs to plant	1.84	13.10	1.43	11.64	1.67
Coal at from $1.25 to $1.41 per ton	6.31	13.30	4.47	4.31	3.28
Oil, waste, &c	0.52	1.55	0.75	0.86	0.36
Total supplies	6.83	14.85	5.22	5.17	3.64
Grand total per car-load	54.47	91.19	47.53	62.26	59.75
Cost per yard at 8 yards per car	6.43	11.40	5.94	7.79	7.47
Add per yard for interest on cost of plant	1.00	1.00	1.00	1.00	1.00
Cost per yard including interest	7.43	12.40	6.94	8.79	8.47

DISCUSSION.

Mr. Talbot.—By using the principles of the Burkli-Ziegler formula quoted from Trautwine by Mr. Hill, and assuming the same velocity through the culvert as in the stream above, I deduced the formula

$$\textit{Area of water-way in sq. ft.} = C\sqrt[4]{\left(\begin{matrix}\textit{Drainage area}\\ \textit{in acres.}\end{matrix}\right)^3}$$

where C is a co-efficient depending upon shape of basin, slope and other conditions, averaging $\frac{1}{5}$ in rolling agricultural country. I have found this formula more satisfactory than Myers'; the co-efficient can be easily determined for any particular region. The great slope of Mr. Hill's culvert will add materially to its discharging capacity. Mr Hill has constructed with astonishing cheapness.

HYGIENIC ENGINEERING AND ARCHITECTURE.

By GEO. N. KREIDER, M. D., of Springfield, Late Member State Board of Health.

The large and interesting meetings which I understand your society has already held and the interest which the general public has taken in them, are proofs on the one hand of the pride which you take in your profession and on the other hand of the influence which you are exerting upon the general welfare of the people. As a member of a profession which has ever recognized the value of your services and gladly availed themselves of them, I congratulate you on the success of your meetings. I esteem it a privilege to call your attention to some points in which you are or should be interested, and through this medium to arouse the people to a realization of their own necessities and dangers.

Peace hath her triumphs no less great than those of war, and never has this legend been better exemplified than in these times of almost universal military quietude. The strife now is against disease, or rather against the development of diseases which slay their thousands where the sword and gun destroy their hundreds. All the highly civilized nations of the world are moving in this strife with greater or less success, and that nation will lead in the race for supremacy which has her soil and inhabitants in the best hygienic condition. Providence permits such a pestilence as cholera to feed on the filthy cities of southern Europe in a terrible manner, and thus

to serve as a warning to those countries not yet invaded. Its command is, Be thou clean! The reward of the fulfillment of this injunction is freedom from not only cholera, but typhoid fever, diphtheria, and other diseases which exist in epidemic form; and thus cholera becomes a blessing not disguised. Representative men of the medical profession, as Koch, Pasteur and Sternberg, are at short intervals discovering the causes of the various ills to which human flesh is heir, and are indicating the means by which they can be avoided. They find that most of them are caused or aggravated by certain conditions of soil or dwelling or surroundings. To change these conditions the various arts and sciences must co-operate. Engineers and architects must take up a large share of this difficult and responsible work and solve its problems as they have solved many in the past. The drainage of a swamp in the neighborhood of a certain town in England reduced the mortality from 30 to 20 per thousand, and in a particular part of that town the mortality is but 17. The architecture and construction of houses common in Germany makes them damp and causes more rheumatism and pulmonary troubles than in other countries.

During the sanitary survey of Springfield a certain house, situated at the foot of a small elevation, on the summit of which was located a full and foul privy vault, was reported to the board of health. The cellar was damp and the well at the foot of the hill unfit for use because of the surface water which made its way into it. These nuisances were all ordered removed, but because of the penury of the city authorities there was no intelligent officer left in charge to see that the valuable recommendations of the inspection were carried out. Some twelve months afterwards I was called to see a family which had recently moved into the house, and found children, who previous to their residing in this house were healthy, afflicted with a disease which was directly due to the mistaken survey and construction which have been pointed out.

These preliminary remarks may suffice to show the importance of hygienic surveying, engineering and architecture, and now let me proceed to particulars.

The first I will mention is the public highway. Located, as most of our cities in Illinois are, on soil which mingles with water on the slightest provocation to form that delightful and peculiar mixture known as Illinois mud, we should be particularly interested in discovering a means by which public intercourse can be carried on at all times without the disagreeable filth which now accompanies it for many months in the year. Personal cleanliness is the foundation of all hygiene, and I am free to say that the people located in an unpaved mud village or city have little encouragement toward this first step in their own salubrity. In the larger cities the streets after years of use become so impregnated with droppings that they are little more than vast manure trenches, the dust from which is blown into our houses in summer and carried in as mud in winter. I have

been much interested in examining microscopically the dust from a dirt road and astonished to find the amount of organic material it contains. Outside of their value as promoters of commercial business, no better economic investment could be made by our counties, towns and cities than the creation of well drained and easily cleaned highways and streets. It is my firm belief that the health and habits of the citizens of Springfield have wonderfully improved since the laying of our wooden pavements, and I would venture to say that they have already paid for themselves in the saving of lives and doctors' and druggists' bills. They have as yet not been responsible for any sickness, as some croakers predicted, but on the contrary it is my experience that a very large percentage of consumption, diphtheria, and such other diseases as are due to bad surroundings which exist in this city, are found in those portions which are not paved and drained. It is for you, gentlemen, to improvise for this state, endowed with a soil so rich that paving is particularly difficult, a means whereby these indications may be best carried out, both in city and country, and at such a cost that paving may be made general.

The location, construction and care of any house is matter of great importance, not only to the owner and inhabitant, but also to the public, which may be liable through no fault of their own to be injured by a bad condition in any of these particulars. These are trite sayings to you, no doubt, and yet I have so often seen sickness caused or perpetuated by failure to comply with seemingly apparent rules that I am tempted to repeat that the site for a house should be dry and easily drained; at the summit instead of the base of an elevation; not located over an old well or cistern nor on ground which has been filled in with the offal of a community collected during many years. The house should be sufficiently elevated from the ground so as to give free ventilation in all parts under the first floor. It is necessary to devise some means whereby the space between the ground and floor may be properly ventilated without permitting a current of cold air, or as often happens a through and through wind to chill the floors and destroy the health of the children. A common material through which this air is filtered and heated is decomposing manure banked up to the floor level. This by fermentation gives off heat, while at the same time it generates various filth diseases to afflict the inhabitants and community in general.

The material of which our houses are constructed is of particular importance in Illinois and has a bearing upon the health of the people. I have already referred to the deficiencies in the construction of German houses. These consist in thick walls constructed of brick and plaster which retain the moisture and cause a great deal of rheumatism and consumption. Our brick houses have walls not so thick, but unless great care is taken to prevent the absorption of moisture they are just as liable to be damp. It is said that a single ordinary brick will absorb a pound of water. It is very important, therefore, that the ground area of a brick building be provided with

drains and a water table of stone or other material be provided to prevent the rise of the ground moisture; that the walls be furred and the plastering be laid so as to give an air space between the outer wall and plastering. A tight frame house sheathed and covered with a tar paper is, I believe, the particular dwelling best adapted to our soil and climate. All houses should have a large amount of southern exposure, and with this important point in view, the stairway and little used apartments, such as the parlor and closets, should be put on the north side and the sitting and sleeping apartments left so as to receive the southern air and light. I have seen sickness caused by the neglect of this cardinal sanitary principle.

Next a word as regards the hygienic construction of rooms. The present fashion is towards numerous small apartments. Experience teaches that each room should have a good light and sun exposure and be large enough to furnish abundant air space. The ceilings should not be so high as was customary some years ago, for the rooms are then difficult to heat and ventilate. Dust and dirt should find the least possible lodging place and should be easily gotten rid of. With this idea, all the corners should be rounded and the walls so prepared that they can be washed. It is also desirable that our ordinary carpets be dispensed with or rather replaced by rugs which can be subjected to weekly beatings and if they could be made of wash material it would be still better.

The ventilation of all buildings is as yet extremely rudimentary and little creditable to our day and age. In most dwelling houses a system of ventilation has not been attempted. As yet the best means is the open fire-place, and it is such an excellent means of ventilation that we should endeavor to secure the best pattern. In this connection I beg to call your attention to the grate first devised by Count Rumford, who nearly a century ago made the design. It was rediscovered by Mr. Teale, an eminent surgeon of London, who published a paper on the subject in '86. I show a cut of it. By means of this grate as much heat can be obtained as from an ordinary stove; the fire will burn through the night without attention; perfect ventilation of a room can be secured and the cost of heating be not increased. For these reasons the pattern should be extensively used. I have a modification of it in use and can vouch for its excellence. The points are the large amount of fire-brick surface, which retains the heat, and the small amount of iron used. The hot air chamber underneath serves as a means of making the fuel burn from the bottom. I have great hopes that a fuel gas will soon be furnished which will displace the disagreeable and filthy coal and afford perfect ventilation at a small cost. These improvements once accomplished, we will be rid of one source of disease and death which plays no small part in our mortality tables, not to mention the saving which would occur from losses by fire and the destruction of furnishings by smoke and dust.

Another part of a dwelling of great sanitary importance is the

water-closet, and this brings up the sewer question and the water supply. Despite the great improvements which have been made in them, water-closets are a nuisance. I believe they should be dispensed with and earth-closets substituted. I feel certain that some radical change in disposing of excreta will soon be made, and the dry-earth system appears to me to be the best. Now it is difficult in cities to manage this system, but means must be devised here as has been done in Europe for making it available. In smaller places where each house owner has his little plot of garden ground the material is easily disposed of as a fertilizer. Cremation of other garbage is also to be recommended.

With the disappearance of the water-closet will vanish many of the dangers of the sewers. They will then be used to convey only storm water and liquids which will readily pass through, or at any rate not lodge and decompose in them, and this material can be readily disinfected. This would also dispose of the necessity of a separate sewer system. The nuisance connected with our present system does not end with the sewer proper. A filthy stream is discharged into the nearest water-course, and this more or less diluted is used for drinking purposes by the cities located farther down the stream. The awful effects of a contaminated water supply have been most strikingly exemplified during the past year. Pittsburg, Cincinnati, and all the towns along the Ohio River drawing their water supply from that source have had extensive epidemics of typhoid fever, and it is probable that had cholera gained entrance to these places during the past summer its ravages would have been frightful. It is high time that some means were taken to improve our potable water supply. The stream of filth which pours through the canal and river from Chicago is notoriously productive of disease, but luckily not from contamination of the water supply. Peoria and other cities in this region rely altogether on other sources for drinking water.

The water supply of our interior Illinois towns is a problem of great moment which engineers and chemists must solve. Deep driven wells and filtration on a large scale appears to be the solution of this problem. The cost of filtration by the Hyatt system, for instance, or the sand vault, is the objection to this process. It is to be hoped that a cheaper means may be soon devised.

Just one word, however, regarding the cost of hygienic measures. They soon pay for themselves when so constructed as to accomplish the benefits intended. How shall these improvements, if desirable, be effected? By the appointment of qualified men as sanitary engineers in cities and counties. Col. Waring and other gentlemen of this particular branch of your profession are but the pioneers of an army who will soon be required by the public. The demand for Waring's services and the compensation he receives are evidence of their value, and I recommend the study of this branch to your younger members as being not philanthropic but in the near future remunerative.

DISCUSSION.

Mr. Mead—I have put in a fire-place of the kind mentioned in this paper with excellent results Have also put in a dry-earth closet, but it is apt to be neglected. At Rockford we first took our water supply from the river, but found it not the best. A well was then sunk in low ground, contrary to the advice of experts, and at a cost of $25,000 00 or $30,-000 00. Shortly after it was completed it was noticed that the wells and cesspools on high ground were lowered, and an analysis of the water showed it to be very impure and the well was abandoned. This shows the folly of not following professional advice.

Mr Braucher—I see the doctor condemns all water closets, but I believe some are so near perfect as to be unobjectionable.

Dr. Kreider—There are water closets and water closets. Some may be so perfect as not to endanger the health of the household in which they are used, but the excreta from them may reach the sewer and there remain to endanger the health of other households.

THE INTEREST OF ENGINEERS AND CONTRACTORS IN IMPROVED HIGHWAY BRIDGES.

By J. H. BURNHAM, of Bloomington.

If I assume to write as a contractor on the subject of highway bridges, it must be understood that I do so simply as an individual and not in behalf of any organization or society. It is fair to consider you as an organized body, with interests similar or identical. From the fact that I have been engaged in the business of contracting iron highway bridges for over twenty years—being the oldest traveling representative of that interest in the west—it is possible that my length of service entitles me to a right to be considered a spokesman of the class. For the time being, therefore, we will consider ourselves parties to a short discussion of a matter of self interest, as well as of very great public importance.

Taxes are paid for public improvement. These taxes are mostly expended through township, village, city and county authorities. In Illinois, the township or highway commissioners are the officials who expend the largest part of that portion of the public taxes which is invested in bridges. In May 1884, at a state convention of highway commissioners, held in Springfield, the following resolution was adopted: "All streams should be bridged in the most substantial

manner possible. Whenever practicable, bridge abutments should be constructed of the best stone masonry, and we recommend iron tubes filled with concrete, iron bents, posts or piles, as ranking next to masonry. Whenever neither of these foundations can be used on account of their cost, we advise the use of red cedar, oak or cypress piles, or bents, in the order named. For bridge superstructure we advise the use of stone arches and iron bridges whenever they can be afforded, and we suggest that in order to improve our bridges, while endeavoring at the same time to improve our roads, it will be best to give very careful consideration to the economy of stone and iron bridges as against those of perishable material" Now here is a very emphatic public declaration of the proper authorities in favor of improved highway bridges. This declaration can be carried into effect mainly through the instrumentality of your society when called upon as civil engineers in charge of the letting of contracts, and by the contractors who contract such work. In effect these highway commissioners or other proper village, city or county officials, either alone, or in conjunction with their engineers, are one party to the construction of bridges, and the contractor is the party of the second part. The practical question before us, therefore, is, how shall we, as contractors and engineers, best carry out the public demand for improved bridges?

In order to help understand the situation, confining our examination at this time wholly to iron bridges, let us see in what manner those now in use have generally been introduced.

Engineers, as civil engineers and not as contractors, unfortunately have had but little opportunity in the past to influence the selection of improvements in the line of highway bridges. It is but a few years since the large majority of those who were in ordinary practice were giving very little attention to the subject of iron highway bridge designing. This was mainly because the question was a new one and because the methods of practice were so constantly changing that engineers as a class had no opportunity of being informed. Added to this was a lack of demand for their services on the part of the public officials, and, it must be confessed, something of a spirit of hostility towards civil engineers on the part of contractors.

Instances are, however, not wanting where engineers, as superintendents, have influenced the construction of numerous first-class stone arches and iron highway bridges. I have in mind one engineer, not now a resident of this state, who can point to at least twenty iron highway bridges, each one of a superior type and of unusual strength, which but for his explanations and demonstrations might have been of perishable material, or, if of iron, of a capacity so low that the next generation of engineers would be obliged to grapple with the question of the probable lifetime and security.

It is the contractor, and by the term contractor I mean manufacturer and contractor combined, who has been the agent for the

introduction of perhaps four-fifths of all the iron highway bridges in this state. In this introduction he has performed his full share of exertion, exertion of tongue, of mind, and of muscle. He has visited the locality where a new bridge was needed; he has argued with the officials and leading tax-payers, and pictured the advantages of a permanent bridge as against the poorly built old-fashioned, perishable, washawayable structure, in which the taxes of the past had been invested. He has, at his own expense, taken the officials to see iron bridges and has given the editor of the local paper some reason to be in favor of better public improvements. He has influenced the passage of laws giving more authority to the town officer. He has issued circulars by the ten thousand, indicating the advantages of permanent bridges and incidentally alluding to the powers and duties of town officials in such a way that the meaning of the law has been made manifest. He has helped carry suits into courts in order to assist in making plain the intention of the statutes, and has then published the results as widely as possible. He has furnished printed blanks to guide the officials, attended their meetings, lobbied with boards of supervisors for county aid to townships, made estimates of cost without number, and has left no means untried to introduce his wares, lowering himself it may be nearly to the level of an ordinary peddler in his anxiety to give the public the benefit of the best modern improvements. Even if a competitor has in the end secured the coveted contract, he has captured his full share of the prizes going, and has perhaps gathered quite his own proportion of the harvest.

As a matter of course he has done all this from the low motive of self interest, and in its performance he has made many mistakes. He has been most of the time a pioneer in a business which has at last become well understood, but which has groped its way through a long period of peculiar uncertainties. These mistakes have sometimes been rectified at the cost of the manufacturer, but in many cases the contractor has dropped out of the race, his place to be taken by a more practical party offering an improvement, studied up from the failures of the past. Now why has it happened under this system that these mistakes were not oftener made? How is it that iron highway bridges, introduced mainly in the manner indicated, though sometimes by a contractor who was himself an engineer, have become so popular with the general public that in most cases they now recommend themselves and are called for without much further effort on the part of the contractor? My answer must be, because contractors in general, as a class, have seen that their highest interest was in conscientiously furnishing the best possible bridge for the money paid. But for this their occupation would have been gone long ere this, and it is to their interest that all future structures be built on the latest approved scientific principles, ensuring all possible permanency, and giving the best public satisfaction.

You can assist yourselves and the public by aiding the contrac-

tor in this work. You can, when engaged as superintendents or engineers for public officials, exert to the utmost your knowledge and influence towards creating a demand for the best structures. In doing this, you will be obliged in many cases to urge the making of more liberal appropriations, or the raising of larger taxes. You will do well to call the attention of public officers to the declaration quoted above, solemnly voted by their representatives in convention assembled, and to urge by every argument known to the profession the construction of the best bridge for the locality or community for which you are employed. You now represent districts differing vastly in their needs and capacities. On the Wabash and the Ohio, in Jasper and Wayne and many other counties, you are aware that large taxes for bridge purposes are not easily levied; and if you live in those localities you may be obliged to confine your efforts to superintending the construction of the best obtainable wooden bridge on a light iron or a good wooden substructure. If your home is in St. Clair, Madison, Will or Kankakee, you will find a willingness to pay road and bridge taxes, added to opportunity to procure good masonry substructures, and you can often induce the building thereon of a good modern iron bridge superstructure. If you live in LaSalle, Ogle, Kane or Adams, or similar counties, you will find these combinations existing in their most favorable conditions, and you can safely insist on the adoption of the very best specifications for both sub-and superstructure, confident that the better part of the taxpayers will commend you on the completion of the work, that posterity will not forget you, and that the contractor will rejoice to have his name connected with a permanent structure whose excellence will incaease the demand for more of the same kind.

It is not safe for the public to rely on obtaining its money's worth without the assistance of an expert, and yet as a matter of fact, there are on record a vast number of instances where contractors, who as a class are as good as (and no better than) ordinary human beings, have, when the officials were unassisted by expert talent, actually advised and carried out the very best possible expenditure of public funds at the very least possible margin of profit. But this should not be allowed to stand in the way of the general proposition, that the public has a right to demand of its officials that they call to their aid educated, impartial, competent, well-trained experts when important permanent improvements are to be undertaken.

This demand is founded on reason, and is, therefore, right, as a little reflection will show. These officials in most towns and cities are chosen mainly to attend to the common, annual, simple construction or repairs of roads and bridges, and to superintend ordinary small expenditures. The building of an important bridge, in most places, is an extraordinary event, generally coming up after the officials have been elected, and it is but reasonable to suppose them, in many cases, ignorant of the best way to proceed to purchase, in the legal manner, the best bridge called for by the circumstances of the

case. I wish, therefore, as strongly as possible, to urge the public to demand of their officials when building important bridges, that they purchase, and pay liberally for, the services of well-trained experts, and to insist that both sub-structure and superstructure be constructed on well-known scientific principles; the more stringent the requirements of these experts, the more probable is it that all contracts will be finally placed in the hands of contractors or manufacturers possessed of the best facilities for carrying out the most stringent specifications.

In this manner will our mutual interests be advanced, while at the same time the tax-payers' interests will be better attended to, and the officials will be partially relieved of a responsibility which very few of them have any desire or ability to bear.

Those among you who have given special attention to the study of bridge construction, are already well informed how their services can be made valuable to their employers, but those who have been unable to pursue the subject technically can, nevertheless, effectually perform most of the duties required. For twenty-five cents you can obtain a copy of Cooper's specifications or some others as good or better. With these you can decide on the superstructure of the class of bridge desired, whether A, B or C—city, surburban or country, and can proceed intelligently to let your contract. Any highway iron bridge contractor in the country can understand your requirements, if you will state the capacity you wish for a given length and width of roadway, and number of spans, and in your notice state the class of bridge you wish according to Cooper's specifications, all details to be as therein specified.

Brief as is this recommendation, it will be found practicable and easy to be followed by those who have given little attention to the subject, while even those who are bridge experts will find under this plan but few points open to criticism or improvement.

These remarks are of course intended for application only in a certain class of cases. There are localities where little can be accomplished as yet in this direction, and there are a few cities where the very finest specimens of the highest art of bridge building are demanded and constructed, but the great field for improvement lies between these extremes, and this field should, and probably will, be more or less thoroughly cultivated during the lifetime of the present generation of contractors and engineers. We should labor harmoniously and unitedly, certain that our efforts in the direction of self interest if conscientiously performed will at the same time tend to the benefit of the public.

When I look back on the bridge improvements (experiments I had almost written) of the last twenty years, comparing the iron bridge of 1867 with that of 1888, it does not appear possible that future improvements in bridge designing can keep pace with what has occurred in the past, and yet I have faith to believe that the iron bridge of the future will be as far ahead of that of the present, as

the bridge of to-day is superior to that of forty years ago. In bringing about these improvements, in planning for economy of material whether in iron, or steel, or both combined, in designing so that the injury from vibration and rust will be brought to a minimum, and in convincing the public that the science of bridge building is approaching as near as possible to perfection.

I believe your share as engineers or superintendents will be scarcely second to that of the contractor or manufacturer, and that by our combined efforts we may in the highest and best sense carry into effect the resolutions of the highway commissioners quoted at the beginning of this article, and then will the interests of these officials, the interests of the tax-payers, your interests as engineers, and ours as contractors, become as they should be, harmoniously identical.

DISCUSSION.

Governor Oglesby.—Would it pay to put in iron bridges over our small streams, say from 6 feet to 15 feet span? Would you recommend iron for such spans?

Mr. Burnham.—No. I am not prepared to recommend their adoption in all places; the time has not yet come for them. In considering the comparative economy of wooden and iron bridges, one thing is generally overlooked, and that is that when wooden bridges are used they must be frequently replaced at public inconvenience, and the old structures are generally used for a time while unsafe.

Mr. McClanahan.—What is the greatest width of flagging you would advocate for covering culverts, where flagging is 10 inches to 12 inches thick?

Mr. Burnham.—That is difficult to say.

Mr. Ela.—That depends altogether upon how much earth is over the flagging.

Mr. McClanahan.—I had one case of a 6 foot span, 66 feet width, in which the walls had a foundation of concrete 1 foot thick on clay bed, the walls being three feet wide at bottom, with a batter of 1 inch per foot on inside. On top of the flagging was 9 feet of earth. I was afraid of the weight of the earth on top, so cut holes in the walls and inserted iron rails beneath the flagging. Was afraid to risk the 6-foot span.

Mr. Baker.—If the flagging was average limestone, the factor of safety without the iron rails was something like 10 to 15, which is certainly sufficient.

Mr. Hansel.—There is no question of the desirability of having stone or iron for bridges when we can have them. The original cost is all that prevents us from having them. Criticisms on railroads for not using them are often unfair.

Mr. Baker.—I have here a copy of the specifications of which Mr. Burnham speaks for examination. The requirements of highway commissioners is that the best stone masonry be used. I think they make a mistake in using stone instead of brick, particularly in this state where stone is scarce. Nothing is better than good, hard brick, such, for example, as are used in pavements, laid in neat or high grade cement mortar.

Mr. Hill—I would like to know the cost per cubic yard of brick laid in neat cement.

Mr. Baker.—On the Cincinnati Southern railroad the brick work cost $8.50 per cubic yard face work, backing cost $7.00 per cubic yard; on the Croton aqueduct the average cost was $10.00 per cubic yard. At Chicago the cost is $7.00 per cubic yard.

Mr. Loring—We are taking down our brick masonry on bridges and replacing by stone, as the bricks show many bad cracks.

Mr. Clark, of Springfield.—The trouble must be in the foundations, as good paving brick will stand as much as stone. In short culverts I would unquestionably use brick. Concussion is more apt to break stone where there is little covering above.

Mr. Burnham.—At Watseka there are two bridge abutments, one fourteen years old and the other ten years old. Both are doing well. The Illinois Central railroad has put in brick; this was taken out and replaced by stone. An arch at Bloomington crushed by wet earth above it and was replaced by a wooden trestle. Several on the road are doing well. One brick arch, 10-foot span, on the C. & A. railroad is doing well. I know of one instance where a brick pier put in in 1869 crumbled in 4 or 5 years, and in 10 years was replaced by iron. This failure was caused by poor brick. Good, hard brick in cement is the thing if the work is well done.

Mr. McClanahan.—I know of a case where running ice in a river has broken stone out of a pier. Now will the brick stand as well as the stone in such a case?

Mr. Ela.—It will if well laid.

Mr. Baker.—What mortar was used in the pier of which you speak?

Mr. McClanahan.—Two-thirds sand and one-third cement—Port Barry, Akron, and a third brand from the east.

Mr. Baker.—You can get mortar of a much greater strength.

Mr. McClanahan.—In this case the stone itself was broken.

Mr. Baker.—The brick made nowadays are better than anything except the best stone, to resist crushing. At Chicago they find that for large buildings brick will stand fire better than stone, will withstand the effects of frost better than any stone except granite, and is less affected

by water and the atmosphere than any stone. I am speaking of the best modern brick, and not the poor brick of a few years ago In piers tested at Watertown it was found that the strength was increased 70 per cent. by the use of Portland cement instead of lime mortar, with an increase in cost of only 5 per cent. Piers 1 foot square stood 20,000 pounds per square inch. The bricks were 12½ times the strength of the mortar. There was no difference in the bricks that stood 20,000 pounds per square inch and those that stood 12,000 pounds, the difference in mortar making the entire difference in strength. The failure of brick arches is usually caused by poor foundations.

Mr. Hill.—In building a new depot at Indianapolis it was necessary to remove some brick arches, which was found a difficult task, the brick being so tightly bound together by the mortar as to make the work similar to that of quarrying stone.

Mr. Ela.—There are culverts on the Illinois Central railroad made thirty years ago of 3, 4 and 5 rings of brick made out of ordinary surface clay which are still in good condition. Of two at Bloomington, one failed and the other is nearly as good as when built. I examined the foundations of the one that failed and found the bed was not properly prepared and was scarcely below the surface of the ground.

SPECIFICATIONS FOR BRIDGE IRON.

By Prof. I. O. BAKER, of Champaign.

Wrought iron used in bridges is usually required to satisfy conditions about as follows: †"It must be tough, ductile, uniform in quality, and must have a limit of elasticity of not less than 26,000 pounds per square inch. When tested in specimens of uniform sectional area of at least ½ square inch for a distance of 10 inches, it must stand without breaking, the following tensile strains and elongations in the distance of 6 inches:

Kind.	Ultimate Strength in lbs. per sq. in.	Elongation, per cent in 10 inches.	Reduction of Area, per cent.	Cold Bend, about own diameter.
Bar....................	52,000	20	45	180°
Shape	50,000	15	30	135°
Plate	40,000	10	25	90°

It is also customary to specify that if a piece be tested to rupture by tension, the area at the fracture shall not be reduced more than some specified limit, usually 25 per cent.

Observe that in the above four elements are specially noted:—1, ultimate strength; 2, elastic limit; 3, elongation; and 4, reduction of the section at the fracture.

Ultimate Strength. "Ultimate strength" in this connection always means ultimate tensile strength. In the early use of iron, as a building material, it was supposed that the ultimate strength was the only important item; but now we know that the ultimate strength is of comparatively little importance and entirely secondary to the other three factors. A material might possess a high tensile strength and still be unfit for use in bridges. Such material would not stretch to accommodate itself to an unequal bearing, and would be liable to snap asunder on receiving a blow or shock while under strain.

The apparent ultimate strength is affected by the size, form and length of the test specimen and upon tho manner of making the experiments. The effect of the section on the ultimate strength is well illustrated by the following *formula, which is used by several railroads and bridge companies, for wrought iron subject to tension:

$$\text{Ultimate strength, per sq. in. in lbs.} = 52000 - \frac{7000 \text{ area of section.}}{\text{periphery.}}$$

†From specifications for bridges on Cincinnati Southern R. R., 1881.
*Specifications C., M. & St. P. R. R., 1882.

A somewhat similar formula is employed to state the elastic limit and the size of the test specimen.

Elastic Limit. The elastic limit is important, since it is always assumed that a piece having once been strained and relieved, returns to its original length, *provided* the elastic limit has not been exceeded. Also a piece will bear an indefinite number of repetitions of a load, provided the strain is considerably less than the elastic limit; but a small number of repetitions will produce rupture, if the load much exceeds the elastic limit.

Elongation. The elongation is determined by placing the fractured ends in contact and measuring the distance between points marked upon the specimen before trying the experiments. The difference in distance between these points before and after fracture divided by the original distance is equal to the per cent. of elongation. The per cent. of elongation will be less the longer the portion considered; for, with the best of material, a considerable proportion of the elongation is in the immediate vicinity of the fracture. The total elongation is proportional to the ductility.

This ability to stretch when strained is a very important item in selecting bridge material; this property gives a greater ability to resist shock, and also produces a more equitable distribution of stress between several pieces side by side but of unequal length.

Fractured Area.—The reduction of area is obtained by dividing the difference of section before and after fracture by the original area. Notice that it is the original area that is to be used in finding the strain borne per unit of area, and not the area after fracture as is occasionally improperly so used.

The reduction of area is useful as showing the homogeneity of the material. For example a large reduction of area would indicate a soft place at the point fractured. On the other hand a small reduction of area indicates a uniformity of structure. The elongation measures the ductility and the reduction of area indicates the uniformity of ductility.

The present practice is to specify that the reduction of area at the fracture shall *exceed* a certain specified amount, usually about 25 per cent.; thus seeming to be indifferent as to its maximum value. For reasons as above, it seems that the case should be exactly reversed; the specifications should give the *maximum* limit. Good bridge iron, when tested as per the method of the first paragraph above, will give a reduction of area as follows: Bar iron, 40 to 45 per cent.; shape iron, 25 to 30 per cent.; plate iron, 20 to 25 per cent. These quantities should be specified as the maximum limits. It is believed that an examination of the results of tests upon bridge iron will demonstrate the correctness of the above principles.

Cold Bending.—The method of testing iron by bending while cold is regarded by bridge builders as one of the best, if not the best, means of testing bridge iron. The test usually consists of two parts, 1, bending without nicking, and 2, nicking and bending. For

the first it is usually required that the full-sized piece of bar iron shall bend 180° about a cylinder, whose diameter is equal to the thickness of the piece bent, under blows of a sledge without fracturing. In the second case, the piece is bent as before, the nick being on the convex side, until fractured; the fracture must be nearly all fibrous, showing but few crystalline specks or faces.

Testing by bending is very common, due in part probably to the ease with which the experiment may be made. It in a measure covers the same ground as tests made for ultimate strength, elastic limit, elongation and reduction of fractured area.

Notice the recognition of the difference in quality of bar, shape and plate iron.

DISCUSSION.

Mr. Talbot.—I have here a test piece of the kind of iron spoken of by Prof. Baker. It differs from most iron in that it decreases in section about the same in all parts, showing that the iron is very homogeneous. The reduction of area at the breaking point was about 25 per cent , while near the ends it was about 17 per cent. Up to near the breaking weight there was probably not a greater difference than 5 per cent. in decrease at these points.

Mr. Burnham.—What proportion of accidents in bridges occur from imperfection in iron and what from imperfection of construction?

Mr. Baker.—In one report two out of one hundred and fifty-eight accidents were said to be caused by imperfections in the bridge itself. I judge that failures are mostly due to imperfection of workmanship.

Mr. Burnham.—I believe there is very little danger from imperfection in the iron that is made today.

COAL FIELDS OF COLORADO AND NEW MEXICO.

By A. C. BRAUCHER, of Canon City, Colorado.

The rapid development of the resources of the Western States, the construction and operation of hundreds of miles of railroad, the building of cities and towns, together with an almost entire lack of coal deposits throughout a large portion of Kansas and Nebraska, has created a demand for fuel which looks almost entirely to the coal fields of Colorado and New Mexico for its supply, in consequence of which the mining interests have become of great importance.

The coal deposits of Colorado and New Mexico are geologically located in the formations of the Cretaceous and early Tertiary or Lignitic periods, the measures of the Carboniferous Age in this locality being barren of coal. In all, there are from forty to sixty veins, separated by beds of sandstone and shale and ranging in thickness from a mere trace to ten or twelve feet, while farther north are found beds of lignite from thirty to forty feet thick but of poor quality for use as fuel. In general, but one vein will be found which is workable at a given place, the rest becoming insignificant or being replaced by shales in that locality, while a great majority are worthless for mining purposes throughout the field.

The Trinidad coal field is situated in Las Animas county in the foot hills to the north and west of Fisher's Peak, cropping out along the Purgatoire river and branch canons. The vein is the second from the base sandstone, general dip though slight to the southwest. It varies in thickness from four to ten feet, bearing a split in lower portion of vein which runs from a few inches to five feet in thickness, besides several partings and streaks of bony or impure coal. The material of the main split is a black carbonaceous shale where it is thin, changing to a sandy shale and even to sandstone as it increases in thickness. The vein is disturbed in places by "rolls," which are slight irregularities in position accompanied by a change in the coal to a hard, slaty nature of no value as fuel. The general quality of the coal is good, coking freely. The principal mines in this field are at Engleville, Riffenberg and Starkville.

The Raton coal field is situated in the northern part of New Mexico, Colfax county. The vein is the lowest in the series, ranging from three to seven feet in thickness, and outcrops along the Canadian or Red river and branch canons. In places the value of the vein for mining is destroyed by splits, as in the Trinidad field, while numerous dikes add to the difficulty. These dikes, instead of cutting through the vein vertically, sometimes become basaltic intrusions and spread over areas of greater or less extent, cutting out the coal and proving a serious obstacle to mining operations. The coal is hard, non-coking and of good quality. The mines in this field are located near Raton and at Blossburg, N. M.

The Vermejo vein outcrops along Vermejo creek and branch canons and lies about midway in the series. It varies in thickness from four and a half to nine feet, bearing a split of shale of from six to twelve inches in the upper portion of the vein, besides numerous partings and some bands of sulphur. The field is somewhat disturbed by faults and the deep-cut canons extend the outcrop. The coal is soft and burns freely.

The San Pedro field is located in the southern part of New Mexico, Socorro county. The vein varies from four to six feet in thickness and lies very irregularly. Numerous faults and dikes check the field and add to the difficulty of working. The coal is hard, of good quality, and makes excellent coke.

The Canon City coal field lies in Fremont county, Colorado, to the southeast of the mouth of the Grand Canon of the Arkansas. Two veins are worked in this field at various places, the lower vein from three to four and one-half feet in thickness, and the upper one from five to six feet. The lower vein is worked at Coal Creek, Williamsburg, Rockvale and Oak Creek. The coal is hard, clean, and of excellent quality. The upper vein is worked at Spring Gulch and Canon City. This vein dips strongly to southward, being worked by means of slopes. The coal is of a hard, curly texture, almost without grain, and burns free and clean.

At Walsenburg two veins are being worked,—one of three feet, a hard, semi-anthracite coal;—the other a vein of soft coal of from six to eight feet. These veins dip strongly and are worked by slopes. Other mines are located at Crested Butte, Rock Springs and places farther north, with which the writer is unacquainted. The coal throughout this field is of good quality, black and moderately hard. The deposits found in Wyoming, Montana and Dakota become softer, of a brownish color, and burn feebly, producing a great deal of ashes.

Colorado being a mining state is very strict in her mining laws, which could be copied and enforced to good advantage in many other states, where lack of proper laws or neglect in their enforcement permits mining operations to be carried on with practically no restriction. Laws requiring the workings of all mines to be mapped to date at least twice a year and filed with the state inspector of mines, showing plan of working, ventilation, etc , together with land lines and ownership of property, should be made and enforced in connection with all mining operations, both for the protection of present owners and for the information of future generations as to the lands from which mineral has been taken.

DISCUSSION.

Professor T. B. Comstock warmly commended this paper and expressed the hope that others might be induced to follow Mr. Braucher's good example. He also gave an outline description of the coal fields at Rico, Monera and Durango in southwestern Colorado, with references to the deposits at Crested Butte and elsewhere in Colorado, touching also upon the lignites of Wyoming and adjacent territory. These all belong to the Cretaceous or Tertiary Age. There is considerable variety in the quality and characteristics of the coal from different sections and even from different neighboring mines. Some details were given of the speaker's own experience with the coals and cokes of southern Colorado.

HIGHWAY BRIDGES.

By J. O. WRIGHT, of Lafayette, Indiana.

There is perhaps no department of our public works in which more money is absolutely wasted and there is a greater need of reform than in the construction of ordinary highway bridges by our present method. The work is usually entrusted to commissioners or supervisors who have no practical knowledge of and little experience in bridge construction. However honest and conscientious they may be, the want of information concerning the work and the methods under which they are compelled to operate frequently make them very expensive public servants. Either a competent civil engineer is not at hand when wanted or they think it would be extravagant to employ him to advise with them, plan their work and superintend its construction. As a rule they are intelligent and thrifty farmers who manage their own business with judgment and discretion, and who for this reason have been selected to take charge of the affairs of their township or county. They have had neither time nor opportunity to study the subject of bridge building, and in many cases cannot distinguish between a Pratt truss and a Howe truss, and don't know a channel bar from an I-beam. It is absurd to expect such men to decide what their townships most need and to examine the various plans and specifications submitted. The company whose agent can bring to bear some outside influence or the one having the most attractive picture of the bridge, secures the contract. Fair and honest work must stand aside when strategy and boodle compete for the prize.

The present system of bridge letting is, to my mind, ill-advised and very expensive to the public. In most states the statutes provide that all bridges costing more than five hundred dollars shall, after due notice by publication in some newspaper of general circulation, be let to the lowest bidder. This on its face seems to be a rational method; but any one acquainted with its practical workings must know that such is not the case.

The commissioners, having complied with the law by advertising in the county paper, proceed to notify by mail such bridge companies as they happen to have knowledge of that on a certain day at noon they will receive bids for a bridge 120 feet long and 14 feet wide. Sometimes they tell whether they want an iron or combination bridge, but generally the length of span and width of roadway is all that they have decided upon. About the day preceding the letting, the agents of the various bridge companies begin to arrive with satchels full of diagrams and strain sheets, plans and specifications

for all kinds and styles of bridges, and proceed at once to skirmish around and ascertain about the kind of bridge that is most likely to please the commissioners. Not being able to secure the information desired, each agent submits two or three different plans with prices to suit, and anxiously watches the proceedings till the commissioners in some way indicate the style of bridge they most fancy. The agent of this particular bridge, if he be a good talker (and most bridge agents are good talkers), proceeds at once to show wherein his bridge is superior to all others. The less regard he has for the truth the more convincing he can make his argument and the more easily secure the contract.

In many cases there is a previous understanding among the representatives of the different companies present as to how much each shall bid and just who shall have the contract. Under such an arrangement there is no competition and the county not only pays the actual cost of the bridge, but the travelling expenses and hotel bills of each agent present, besides a profit to each company represented, thus making the bridge cost several hundred dollars more than it is worth. If such an arrangement can not be effected and the bridge is let at a very low figure, what does the successful bidder do, put up a bridge for nothing or lose money on his contract? Not unless he is strictly honest and wishes to maintain his reputation. He uses a channel bar 8×10 inches weighing 20 pounds per lineal foot instead of 24 pounds; or an I-beam weighing 14 pounds per foot instead of 16 pounds. This reduction in the size of the members throughout the bridge effects quite a saving in the cost of the material, but at the same time greatly lessens the strength and durability of the bridge. Instead of a capacity of 100 pounds per square foot of floor surface, as specified, it will not sustain 75 pounds under the same conditions.

The reductions are made in such a manner that the commissioners are not able to detect the fraud. In nine cases out of ten when notified that the bridge is complete ready for acceptance, they drive out and look at it but make no tests nor examination whatever. The contract and specifications are carefully filed away and have not been looked at since the day of the letting. If the agent or contractor is particularly anxious to make himself solid with the board so as to secure other work from them he happens around and goes out with them to inspect the bridge, takes the specifications along and with rule in hand measures the different members and calls particular attention to the fact that they are the exact size specified, but never suggests that the sectional area has been greatly reduced. The commissioners think they have gotten a good bridge at a very low price.

So far as my experience and observation go, the practical result of this law has been to destroy competition and secure poor work, unless there be a competent and efficient superintendent in charge. The system I believe is wrong in principle and should be abolished.

If a farmer wishes to purchase a watch he does not buy a book on watch making and sit down to study the construction and requirements of a good time-piece. He simply decides whether he wants a silver or a gold watch, open face or hunting case, and leaves the rest to some man whose business it is to make watches. Neither does he notify all the dealers in town that on a certain day he will receive proposals for furnishing him an open-faced gold watch. He goes to some well-established and reputable dealer in whom he has confidence and pays a fair price and gets a good article. He might possibly have gotten just as good a one from an auctioneer on the street corner for a few dollars less, but he does not visit him, and why? Because the risk is too great, knowing nothing about a watch he prefers to deal with some one who has an established reputation for fair dealing and honesty. He believes a reputable jeweler can sell goods just as cheap as an itinerant peddler, and if, perchance, he pays a little more he has the satisfaction of knowing that he will get just what he bargains for. It seems to me that the same prudence and judgment ought to be exercised by the commissioners in purchasing a bridge.

There are throughout the country some honest bridge builders who do first-class work and the number could be increased under more favorable conditions of operation. They would be glad to make and sell good bridges at a fair profit, but their trade is hampered by the law requiring public bridges to be let to the lowest bidder. They are compelled to enter into competition with irresponsible agents and paper companies, who take work at any price and then farm it out to some blacksmith or machine-shop for construction. So long as this practice continues there is little chance to improve the quality of our bridges.

The remedial suggestions that I have to offer are not entirely new, but a repetition of them may do something toward reforming the present practice. In each state there should be a *Board of Public Works* composed of three or five members of character and ability —say one architect, one mechanical engineer and one or more civil engineers. They should be men of high standing and large practical experience in their several departments. The board should be entirely removed from politics and the members thereof should hold their positions during good behavior. The plans and specifications, together with the contract for all public work of any importance done by the state or counties, such as court-houses, jails, asylums, bridges, &c., should either be prepared by this board or examined and approved by them. They should have facilities for and make frequent tests of the material offered for use as to its strength and durability, and should be required to examine thoroughly each structure erected and certify that it is fully completed in all respects according to the plans and specifications before the same can be paid for from public funds. The creation of such a board would in a short time greatly reduce the annual expenditure and at the same time improve

the character of our public works. It would do much toward elevating the profession of engineering and bring the services of competent men into greater demand.

Another move in the right direction would be the adoption of a standard specification for highway bridges of different lengths of span and net capacity. The style, size and working stress of the different members should be determined by representatives from the several engineering societies and adopted and used by all reputable bridge companies. The length of span made should increase in some regular order like the size of bolts or nails. There is no more necessity for a bridge 117 feet long than there is for a 5-7 bolt or a 13 penny nail. Each may be convenient at certain times, but is not absolutely necessary.

It will take long years of agitation and many more serious bridge disasters before the busy people will stop to consider these or any other suggestions looking to greater security in matters of public safety.

Let us now consider for a short time the best method of procedure under existing circumstances. The first thing to be done is to employ some local engineer to look after the matter, and if he is not entirely competent to take sole charge of the work, he should gather all the facts possible in reference thereto and consult some engineer who is, and under his direction prepare complete specifications for the kind of bridge needed. It should be distinctly understood that every piece of iron when brought upon the ground should be weighed or measured, and if not the size stated in the specification, should not be used. One or more pieces should be selected at random and sent away to be tested, and if its strength is not found equal to that specified, the entire iron work should be rejected. Now and then a rivet should be cut out to see that they completely fill the holes, and the entire workmanship should be subjected to the most rigid scrutiny by the engineer in charge. Such requirements will secure substantial bridges.

There are some matters of importance that must be determined by the local engineer. I wish to call your attention, briefly, to a few of these points. The first questions that confront the engineer are: In what position shall this bridge be located? Shall it be at right angles to the stream, or slightly askew so as to align with the highway? What length of span is necessary, and what kind of a structure is best adapted? These are apparently simple questions and too frequently receive little or no thought, while in fact they are most important matters.

A bridge properly located is half constructed. There are no infallible rules or formulæ for determining what constitutes a proper location. I would suggest that more time be spent in determining this question. View the site from up-stream and from down, from right bank and from left. Locate your bridge in different positions and note the objections and advantages of each. Do not build in a

certain position just because the old one was in that position. I can best show the importance of this point by a case that came in my practice a few years ago. I was employed to prepare plans and specifications for rebuilding an iron bridge consisting of three spans of 120 feet each that had recently been carried away by high water and floating ice. I visited the site and found a mass of loose stones and mortar, and a network of broken and twisted channel bars I-beams and rods. The piers had been leveled to their foundation. On examination I found the sole cause of the wreck to have been due the location of the bridge. The stream made a sharp curve just above and the piers had been so placed that the current struck them obliquely and forced them off their foundation. This blunder cost the county $9,800, and had any mature judgment been exercised in locating the bridge the loss could have been avoided. This is but one of many illustrations I could cite, but hope it will serve to impress the younger members with the importance of giving plenty of time and thought to locating any structure, bridge, ditch or road.

Another matter requiring care is the selection of the length of the span. In order to reduce the first cost of a bridge, it is frequently shortened and shortened till there is not sufficient opening left in case of high water, causing damage to the foundations and approaches if not a complete destruction of the bridge. A safe rule is to get the area of the opening required for the highest water known and then add at least $33\frac{1}{3}$ per cent. as a matter of safety, and with swift current I would add even more. It is better to have a bridge ten feet too long than five feet too short. In some cases the amount saved by shortening the bridge is more than over-balanced by the additional cost of the approaches.

The next step to decide is what kind of a structure shall be adopted. This, of course, must depend somewhat upon the amount of money that is available for the purpose, but more particularly upon the length of spans and the character of the surroundings. For example; I would not think of putting in the same kind of a foundation and superstructure over a stream with high, steep banks and a swift current that I would over a sluggish stream with low banks in a level prairie. The engineer must acquaint himself not merely with the surface indications but with sounding-bar and auger.

Plans adopted without a thorough examination of all the details are frequently found to be impracticable after the work is commenced, and have to be abandoned. This always proves to be an expensive procedure and should never occur in the practice of an engineer. Examine minutely the character of all the surroundings, work out your plans to their remotest detail and when the contract is once let and the work commenced, "fight it out on that line if it takes all summer."

BRIDGES AND VIADUCTS FOR CITIES; THEIR SELECTION AND MAINTENANCE.

By D. W. MEAD, of Rockford.

When a road is carried by a structure over a valley, in which a water-way plays little or no part, the structure is called a viaduct. These structures differ from bridges only in this particular. In bridges the difficulty of securing a foundation for piers or the necessity of leaving the water-way unimpeded frequently makes long spans necessary or desirable; while in viaducts the supports, being usually built to withstand only the strains brought upon them through the superstructure, can be made much more cheaply, and hence shorter spans can be used. We may state more briefly that bridges are built where filling is impossible, and viaducts where it is undesirable. The most of that which follows will apply to either bridges or viaducts.

There are many factors which must be taken into account in the selection of these structures. Local and conditional circumstances must largely decide the choice of material and method of construction in each particular case.

The element of durability must be taken into consideration. No material will render a structure indestructible, but materials vary greatly in durability. Iron, conditions being favorable, is reduced to an oxide and loses its valuable physical qualities. Wood, likewise, undergoes a slow combustion and becomes useless. Certain mineral constitutents of rocks undergo like changes causing disintegration. The principal physical agencies are, the expansive power of ice; the dissolving power of water, increased by the presence of acids in solution; the atmospheric agencies, as aqueous and acid vapors, wind, sun, heat and cold. Moreover the actual physical work which the structure does must also be taken into account. A structure then depends for its length of existence upon, first, the material, and second the design. The materials used for bridges and viaducts may be classed as follows:

1st. Stone and its nearly related allies, brick, concrete and other earthy materials, structurally called masonry.

2nd. The metals—principally iron and steel.

3rd. Wood.

These materials are used singly, but more often in combination.

Masonry structures as a rule are the most durable; that is, they generally deteriorate less rapidly. One reason is that the constituents

of the materials are usually very stable compounds and are not easily affected by the common chemical agencies. Physical destructive agents are more active. Although no infallible rule is known, non-absorbent, fine-grained material having a high specific gravity should be chosen. The best test is the test of experience as derived either from structures long in use or from the natural outcrops. It must be remembered that much depends upon the proper selection of material, and the amount of this care should be governed by the importance of the structure. When properly designed, I consider masonry the most satisfactory material for bridge work, whenever the local condition, expense, &c., will warrant its use. Its chief advantages are great rigidity, durability, safety and small cost of maintenance. The principal objection is first cost.

Next in value to the masonry arch is the iron beam bridge with masonry piers; to this I would call your special attention. This may be made in several ways,—with joists and planking on top of the beams, or with buckle plates or brick arches between the beams and some kind of pavement for a surface. In these last forms this bridge approaches the stone arch in character and has in some places the valuable advantage that it gives a greater amount of water-way. The plate girder will allow the use of a longer span.

Wooden beams are also used in the same manner with spans as large as the cost of material will warrant. Wooden beam bridges are most commonly supported on trestle or pile bents, although masonry is of course more desirable. In Rockford they are used on small creeks and dry runs on the outskirts. Twenty feet is our usual limit of length. Beam bridges require no adjustment. They are not liable to get out of order and they have no weak points. Simple calculation of the requisite strength and a construction which will retard their destruction by the elements is all that is necessary.

For long spans, trussed bridges are necessary, and for short spans they are not unusually adopted. The almost universal American type of iron truss bridges is the pin-connected truss; for cheapness and rapidity of construction and erection, they certainly have no equal. They have also the supposed advantage of certainty of a knowledge of the manner in which the strains are distributed. However, it is noticeable that riveted details are coming more and more into use, and that many bridges having riveted connection throughout are being erected. It is believed that where the extra expense is allowable the riveted form has advantages which will more than balance its acknowledged defects. A pin-connected bridge well designed in all its details, well constructed in the shops, properly erected and adjusted, and well maintained, is certainly a fine structure, but it is believed by the writer that a riveted bridge designed, constructed and erected equally as well has the advantage of greater safety. In the pin-connected bridge as usually designed there is a mutual dependence of the parts; each part takes its share of strain which no other part can. Hence, if one part is useless the whole

structure becomes so. If one portion of the structure is broken or torn out the whole bridge falls.

Only a short time ago, on a southern railroad, a derailed freight car knocked the end post of a bridge off from its abutment and as the bridge was pin connected the whole span, cars and all, went into the river. The probabilities are that this would not have occurred in a riveted bridge; the stiff bottom chord would have kept the structure in place, and if not, the other three shoes would probably have sustained the bridge. Some years ago the same thing happened on a highway bridge from the shock of a runaway team.

The great objection made to riveted bridges is the uncertainty in regard to strains, whether one part or another takes them; this very defect is the point which has frequently proved its safety. Several years ago, I believe on the New York Central R. R., a derailed car tore two of the inclined members from their connection with the bottom chord of a riveted bridge and did much other damage, yet the bridge successfully sustained the shock. Riveted connections give a stiffness to a bridge which aids greatly in preventing the accumulation of vibratory strains. As previously stated, their advantage is being recognized by many constructors who use the pin connection for their principal members. For example, a bridge recently constructed over the Rock River for the Chicago, Madison and Northern R. R. has the post riveted to the upper chord, the floor beams riveted to the posts, the stringers riveted to the floor beams and the upper and lower lateral bracing riveted throughout. The tension members only have pin connection.

Wooden bridges although commonly considered short-lived will last, when properly cared for, a considerable length of time. S. W. Robinson (Van Nostrand's Magazine, May, 1882,) puts the life of best pine railroad bridge at ten years if not covered or painted and at about twenty years if covered by a covering which will completely shed water. Wooden bridges are, however, usually poor investments for municipalities They require careful attention and constant repair after a few years.

In a new and thinly settled country the question of first cost is the most important question. With population and wealth, more attention should be given to permanent works. It is believed that our ordinary structures should ultimately be replaced by masonry, and that, when long spans are necessary and traffic demands a stiffer and stronger structure, riveted work will become the rule rather than the exception.

Maintenance.—When a structure is completed it requires more or less constant care to preserve it in good condition. Masonry is usually more free from the effects of the destructive forces than other material; but often through improper work the mortar joints will become broken and cracked and admit water into the interior which will cause rapid deterioration of the structure. For this reason the joints of masonry should be kept carefully pointed. The

surface of the stone, especially if the selection of material has not been judicious, will undergo disintegration. To prevent this, various plans have been tried, among which may be mentioned the application of paints, oils, paraffine, beeswax, rosins, &c. In the most successful the structure is bathed with solutions which by a chemical action form insoluble silicates in the pores of the material. The structure should first be washed in a strongly alkaline solution to remove the dirt. Then apply, in several washes, a solution of potassium or sodium silicate, and afterward wash in lime water. The result is that insoluble calcium silicate is formed in the pores of the material which will prevent the absorption of water, gases, &c.

Oxidation or rust is the universal accompaniment of iron work, and for the proper protection considerable care is needed. Dry air has little effect upon iron; dampness and the presence of acids seeming to be essential to the formation of rust. Alkalies prevent the formation of rust by neutralizing the acids. Hence iron imbedded in lime does not rust. Many hydraulic cements, however, often cause rapid corrosion of iron. Wet coal ashes cause iron to oxidize very rapidly, and salt has a similar action. Any material for the purpose of protecting iron must be moderate in cost, elastic, durable, adhesive and impervious. The paints, oils, and varnishes best answer these requirements. Too rapid drying should be prevented, as it is apt to cause cracking and peeling off of the paint. Any accumulated rust should be first removed and a coat of hot linseed oil should be then put on; then the paint may be applied. I usually prefer a light color for the outer coat. This will best show when oxidation has again begun. To know when the paint needs renewing is important.

Although there are many processes for the preservation of wood, they are mostly inapplicable to small works. Decay begins usually in the ends and joints of timber, and these should be thoroughly coated with white lead.

The design of both iron and wooden bridges plays an important part in their maintenance, for much depends upon the accessibility of the various parts and the readiness with which they can be painted, repaired and renewed. Care should be taken to have every part open to inspection, light and air. In both the selection and maintenance of bridges and viaducts it must be remembered that success depends more on the proper combinations of varying conditions than on the application of any elementary principles.

[Through Mr Mead's courtesy in assisting to clear up a crowded programme, the foregoing paper was read by title. It is probable that the comparison of riveted and pin-connected bridges would have caused unfavorable comment by many members The subject is suggested for discussion at the next meeting —EXECUTIVE SECRETARY]

SURVEYING—PRACTICAL AND ARTISTIC.

By D. L. BRAUCHER, of Lincoln.

My subject is one that is very interesting to every surveyor. Yet when I undertake to write a paper on the subject that would be interesting or instructive, or even amusing to the members of this society, I am confronted with a task much more formidable than I could have supposed before making the trial.

It has been to me only another evidence of how difficult of solution some very simple and innocent looking problems prove to be on a more careful examination. But practical surveying is full of interesting experiences, so very different to each, individually, that a recital of some of those experiences may prove interesting to others.

It is a well-known fact that the "line of no variation" is not a true meridian, but differs from it very materially, bearing to the northwest and southeast. For that reason in starting from any point with the true variation for that place and tracing a line north or south by the magnetic needle, you will not trace a true meridian.

But I have supposed that, for short distances, the magnetic needle would trace a straight line, when not affected by local or temporary causes. I have in my practice often noticed that the needle would be more or less deflected at different stations on a true line, but I always attributed it to local or temporary causes.

About twenty years ago I had occasion to run a line in Logan county a distance of four and one-half miles. I then noticed that the needle did not settle as uniformly to the zero as it usually does, but I did not think of there being anything more than a local or temporary cause for the deflection. I recently had occasion to run the same line a distance of four miles and I was somewhat surprised to discover the same deflection and in the same direction as before. I also found that the position of corners on that line, standing at time of first survey, conformed approximately to the deflections the needle indicated.

The question naturally arises, What is the cause of this deflection and what weight, if any, should be given to this fact in the location of corners on this line? Since that time several different surveyors have been called to make surveys on that line, which indicates dissatisfaction of the parties interested and that the usual

plan of restoring lost corners by placing them "on line and at equal," or pro-rated "distances between known corners" seems to conflict in this case, with the evidence "of the oldest inhabitant" who locates the original mound (?) at points very materially out of line and measure.

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I have chosen to call the surveying of lawns, landscapes and cemeteries, where the ornamental features were more of an object than exactness of outline, by the name, *artistic surveying.* The first time I was called on to do that kind of work I was inclined to acknowledge that it was "out of my line," but on being furnished with a "working plat" I saw at once that there was nothing easier. The plat was divided into cross-sections of fifty feet to the square, and the ground was staked off in the same way and the stakes were marked by letters and numbers. I then applied my scale to the plat, set stakes at the intersections of the streets with the cross-sections, then carefully adjusting an ellipse in one eye and a parabola in the other, I proceeded to transfer the plat to the ground by *walking in* the curves between the stakes, and when completed I was of course pleased and no little surprised to see how closely the plat on the ground imitated the "working plat" furnished.

In my early experience I was called on to survey a race track. The conditions required it to be one mile in length, having two straight stretches of twenty chains, each tangent to and turning in curves with unequal radii. I shall never forget how hard I labored to solve that problem. But the work was done and when put on the ground it filled the conditions so very nearly that it surprised myself.

Since that time a problem for finding the length of a belt running on pulleys of unequal size called for solution. In solving this problem I wrought out a general formula which will apply to this and all similar cases, and it would have saved me much labor in the solution of the race-track problem if I could have had it for use at that time.

I have modified it in the following formula to suit the conditions above given where $L=80^{ch}$ and $S=20^{ch}$, $a=\frac{1}{4}$ of the difference between the two arcs expressed in degrees:

$$\left.\begin{array}{l} R=[57.2958+\tan a\ (90-a)]\frac{s}{180}=7.6881^{ch} \\ r=[57.2958-\tan a\ (90+a)]\frac{s}{180}=4.7763^{ch} \end{array}\right| \begin{array}{l}\text{when} \\ a=8^{\circ}\ 17'\end{array}$$

But to make the formula general,

Let L=total length of track.

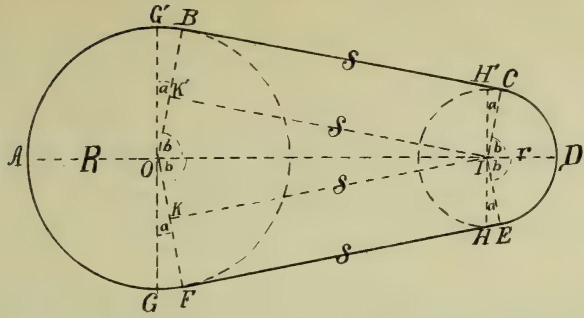
" s=length of one straight side and tangent to curves.

" R=radius of large circle.

" r=radius of small circle.

" $b=\frac{1}{2}$ Arc in small circle expressed in degrees.

And $180-b=\frac{1}{2}$ Arc in large circle expressed in degrees.



$b = 90 - a = CID = BOI$

$a = GOF = BOG' = CIH' = OIK = OIK' = HIE.$

Applying the well-known rules of the circular functions we have the following:

$R\left(\frac{180 - b}{57.3}\right) + r\left(\frac{b}{57.3}\right) = \frac{1}{2}L - S$. and clearing of fractions.

$$R(180 - b) + r\,b = 57.3\left(\tfrac{1}{2}L - S\right) \qquad - \quad - \quad - \qquad (1)$$

But $R - r = s \tan(90 - b) = \cot b \times s$ and $R = s \cot b + r$.

Substituting this value of R in equation (1) we have.

$S \cot b\,(180 - b) + r\,(180 - b) + r\,b = 57.3\left(\frac{1}{2}L - S\right)$ from which

$$r = \frac{57.3\left(\frac{1}{2}L - S\right) - S \cot b\,(180 - b)}{180} \qquad - \quad - \quad - \qquad (2)$$

Since $R = S \cot b + r$, we add $S \cot b$ to the value of r in equation (2) and find by collecting and reducing that

$$R = \frac{57.3\left(\frac{1}{2}L - S\right) + S \cot b \times b}{180} \qquad - \quad - \quad - \quad - \qquad (3)$$

If we put $a = (90 - b)$ and remember that $\tan a = \cot (90 - a) = \cot b$ and then substitute these values in equations 2 and 3 we have using the more exact number, 57.2958, the general formulæ, viz:

$$R = \left[57.2958\left(\frac{\frac{1}{2}L - S}{S}\right) + \tan a\,(90 - a)\right]\frac{S}{180} \qquad - \quad - \qquad (4)$$

$$r = \left[57.2958\left(\frac{\frac{1}{2}L - S}{S}\right) - \tan a\,(90 + a)\right]\frac{S}{180} \qquad - \quad - \qquad (5)$$

When $L = 4\,S$, the factor $\frac{\frac{1}{2}L - S}{S} = 1$, and may be omitted.

If it be required that $R = u\,r$ it will only be necessary to put the value of R in equation (4) equal to the value of r multiplied by u in in equation 5 and then solve for the value of a; which value used in equations 4 and 5 will give $R = r\,u$.

If any value be given to a, there will result corresponding values for R and r which will fill the conditions so long as the value of r is positive in equations 2 and 5, but when r becomes negative, the difference between the two arcs will equal $(\frac{1}{2}L - S)$.

When $S = \frac{1}{4}L = 20$ I find the limit for the value of a lies between 0 and $26°\ 14'\ 21\frac{3}{4}''$; and when $a = 26°\ 14'\ 21''\frac{3}{4}$ r will disappear and the two straight sides will meet in the centre of the small circle.

REPLACEMENT OF WOODEN TRESTLES WITH IRON AND STONE STRUCTURES.

By J. M. HEALEY, of Champaign.

Your attention can be called to few subjects of more importance than that of "timber trestles," now used by many railroad companies for permanent structures.

In most if not all cases, they have been built in the construction of the road, when no better building material was within reasonable distance, and have been renewed from time to time, till they have become a part of the "roadbed." As to their safety, when properly built and protected, there can be no doubt; but the danger has been where they have not been properly rebuilt in time or have been carelessly neglected or forgotten, till they have burned or broken down; when all have been reminded by the terrible railroad disaster. When they have been used as temporary works, for the purpose of opening roads, the practice has been generally approved, because a large percentage of the cost of production was saved by using the constructed road for hauling the materials used to finish the road, such as stone and gravel for ballasting, stone and cement for culverts, the ironwork for bridges, earthwork for grading over culverts, &c.—in fact many of the roads could not have been built in any other way. But as soon as the roads were opened the work of finishing should have been commenced and continued till the permanent works were completed. It would have been for the best interest of all companies, if their roads could have been so built; and it is a question now if some of the roads can be justified in having delayed so long the building of the permanent way.

A timber trestle placed as it often is at the foot of two grades, where trains are run at full speed, or on a sharp curve near the point of some hill, and where the track can not be made to ride smoothly at all seasons of the year, is not what railroad companies should want. As long as the trestles remain in the track they will be a source of trouble and expense; the closest inspection and constant renewals will ever have to be made; most careful watchmen will be required at all times to keep them from burning, and with all, it will be an impossibility to make with them a solid, smooth-riding track, required by all companies for successful operation. As it is the general experience that the best, safest, and most reliable track is that where the ties rest on a solid roadbed of earthwork and are held in place by being well ballasted with gravel or broken stone, would it not be the the better way for all companies who have their tracks

full of temporary timber trestles to take up the subject at once, and begin the completion of the permanent way, by building permanent structures, and solid roadbed over same, as fast as renewals are required? The public understand it to be needed as much as any of the betterments asked for in the heating and lighting of coaches or coupling of cars; and the demand for it will be made. There is no good reason why it should be postponed longer, or why the roads of this country cannot be as well constructed and as safe as the roads in other countries.

For all permanent structures except bridges there is no better building material than stone, when it can be obtained at reasonable cost; but when it cannot, except by a long haul and at great expense, other material can be substituted. For all streams where a ten feet arch will give sufficient water-way, the iron pipe used by the C., B. & Q. R. R. Co. would be as durable as the stone, although the cost might be more. But for all large streams (except the largest) there can be no better or safer structure than the stone arch culvert, when properly built of good stone. In places where stone would have been very expensive, iron piling has been used for bridges of short span and has answered the purpose very well; but for piers and abutments of large bridges, where great strength and solidity are required, there is no substitute for stone. The wood box culvert used in the construction of the road by the C. M. and St. P. R. R. is very much better than the trestle, because a solid roadbed can be built over it; there would be no risk from fire, the danger from washing out would not be any greater and the cost of renewal would be no more. The wooden barrel culvert used by the C., B. and Q. R. R. Co. is also very much better than the trestle, for same reasons—the solid roadbed over it being very essential.

The sewer pipe used in some cases, is better than the trestle; for the reason it will not burn, it will allow of solid roadbed over it, and if there should be any failure by being broken, it can be renewed at small expense without tearing up or endangering the track. The objection to the sewer pipe is, it will be broken by the frosts, if water is left standing in it; and unless it can be thoroughly drained and kept so, it would not be any better than the wood box. Because of the great difficulty in keeping it from breaking, the stone box or iron pipe would be very much better.

The open culvert, though built in a permanent way, with stone abutments and iron girders, and considered very substantial, is far from being as safe as the iron pipe or stone arch with solid roadbed over them; if possible to avoid, the open culvert should never be built. If there is not sufficient depth for the arch, it will be better to make more room by raising the grade line; and a double arch could be used. The cast iron pipes used by the C., B. and Q. R. R. are a good substitute for the stone culvert, and will make the best structures in places where there is no stone. Pipes from two to

seven feet have been used successfully. The Pennsylvania Railroad has been substituting stone arch culverts for some of their short span iron bridges. Their experience in changing their wooden bridges to iron, and then rebuilding the iron to make them stronger to accommodate the ever increasing weight of engines and trains, is very valuable. If from the experience of the past, no safe calculation can be made as to what will be required from iron bridges in the next decade, it will be easy to see the advantage of the stone arch. which, when once built, will last forever.

There are very many small trestles in our western roads, that might be renewed with the stone, box or iron pipe and the cost would be very little more than that of renewing the trestle with timber; and when the grading is made over them, the track will be permanent. In renewing trestles with culverts or pipes, great care should be taken that they are large enough. There have been many cases where culverts were too small and very few where too large. A good formula would be to estimate full size and then double it. In renewing some of the trestlework requiring arch culverts, the difference between the cost of renewing the trestle and the arch will be greater in proportion; still the advantage in having a permanent structure will more than compensate for the difference. There are some cases where small culverts only will be needed, where there are long trestles. For renewing an ordinary trestle of 48 feet under an embankment of 15 feet, it would cost about $185.00 to renew the trestle; when a permanent stone box culvert could be built for $225.00. An 8-foot stone arch culvert under a 15-foot embankment, can be built for about $1,000.00.

All honorable means in the power of civil engineers and railroad officers should be used to perfect and complete the unfinished railroads all over the country; and there should be no letting up 'till the roads of America are as good as those of Europe.

DISCUSSION

Mr. Baker —In the question of iron pipe culverts I would like the opinion of some practical railroad men on how they would like riveted iron pipes?

Mr. Balcom.—Instead of using iron pipe clear through the embankment, could not vitrified pipe be used in central section and iron pipe used in outer sections with success?

Mr. Braucher.—I noticed that in our county the railroads have used vitrified pipe for culverts and found it nearly a failure, for what reason I cannot say. Water standing in the pipes assists in making a failure, I think.

Mr. Hill.—Vitrified pipe are used by us and with good success. We use sizes 18 to 24 inches diameter.

Mr. Ela.—My experience is more failures come from putting in than

from any other cause. If the pipes are laid with fall and outlet so as to properly empty themselves, no trouble will be experienced.

Mr. Wright.—Have had considerable experience with vitrified pipe. The frost lifts up the end pipes and they hold water which freezes. Heavy stone collars should be put about outer sections so as to be secure from frost.

Mr. Balcom.—I had an officer of an old road say to me that the repairs and renewal of the wood culvert were cheaper than the stone culvert and the interest on the cost.

Mr. Hansel.—It is not altogether a question of which is best. The financial condition of a road will often require work to be done in an inferior way because it is cheaper.

PROGRESS OF WORK ON THE OHIO RIVER BRIDGE AT CAIRO.

By S. F. BALCOM, of Champaign.

River systems are spoken of as the arteries of a continent. And it is a true comparison; for the life blood of Nature—that most precious of all elements, water—courses through them. Thirty years ago rivers could also have been said to be the arteries of commerce. From the slow-moving barge on the eastern canals to the fleet, white steamers that plied up and down the Mississippi, the water-ways of the country were teeming with commercial life. How is it to-day? Tow-paths have changed to railroad embankments. and the principal rivers are paralleled by railroad lines. Although the internal commerce of our country has multiplied in a geometrical progression, since the civil war, still the river traffic has steadily decreased. The rapid transportation afforded by railroads has brought into existence the net-work of lines that cover our prairies and climb our mountains. Should our land be threatened with war, the railroad system would be its main dependence. With facilities for transporting large armies to almost any point on our borders. we have little to fear.

Among the most important lines of railroads in this respect, is that of the Illinois Central, extending from the Lakes to the Gulf; the efficiency of which was attested by the numerous "soldier" trains that passed and repassed between Chicago and Cairo during the late war. Since the acquisition of its southern lines, the Illinois Central system has seriously felt the break in its line which occurs at Cairo, on the Ohio River; and to remedy this, a bridge over that river has for a number of years been considered a necessity.

A number of years ago J. M. Healey, Division Engineer of that portion of the road, made a triangulation survey at Cairo, to determine the distance between the head of the transfer incline at Cairo and a similar point in Kentucky. The distance was found to be 4097 feet.

Borings made in 1881 show that nothing but a sand or gravel foundation can be had at or near Cairo Fine and coarse sand, and gravel of the same nature, as well as sand and gravel mixed, exist in strata or beds of from 4 to 20 feet in thickness. Beds of quicksand occur until a depth of 50 feet is reached; lower than that, the sand and gravel for 120 feet is free from it. Sand or gravel, if kept intact, makes a good foundation; and this fact probably secured the location of the new bridge at North Cairo, about one mile up the river from the transfer incline already mentioned.

The land between the Ohio and Mississippi rivers, for some 10 miles or more from their junction, is low, flat, bottom land, and is overflowed each winter and spring during the high water in the Ohio and Mississippi rivers. This land is covered with a heavy growth of timber, among which may be found the cypress, with more knees than arms; the sweet gum, whose deep red and rich bronze tints in autumn rival those of the sumac; the red-elm, with its gnarled limbs and winged branches often thickly covered with clumps of mistletoe. Here is also to be found the cane that fishing-poles and pipe-stems are made of. And covering nearly all the bottom land is a tangle of undergrowth and vines, so thick, that to pass through, a way would have to be cut. From the trees hang festooned the wild grapevine, the trumpet-creeper, the wild honeysuckle, the wisteria, the dreaded nightshade, and such vines as the passion flower and morning-glory. Through this swamp the right of way of the Illinois Central has been cleared, forming a lane through the wilderness,—and a watery lane it becomes at flood time. This is verified by the fact that when the high water of 1881 and '82 made a break in the embankment, a steamer came up to the track from the Mississippi, and transfers of passengers, baggage, &c , were made from the passenger trains to the boat, which in that way were taken to Cairo.

At the southernmost extremity of these low lands, at the junction of the rivers named, is located the city of Cairo. Although not noted for monoliths, as are some cities of ancient Egypt, still this city with an Egyptian name situated in the Nile valley of the new world is entitled to some notice; for, on what was then the southernmost point of land in Illinois, was placed at an early day a modest little monument which marked the starting point of the 3d principal meridian, the most important land line in the state. This line, however, makes a "bad beginning," for, deserting its native state, it crosses the Ohio River into Kentucky! But, after cutting a point off of that shore, it passes back into Illinois; and, dividing the land right and left, it continues to the "good ending" by reaching the Wisconsin line, being the only line of its class which crosses the entire length of the state.

Cairo is protected from high water for some 2 miles on the east by what is known as the Ohio Levee; on the southwest and west by the Mississippi Levee, which is about 3 miles long; on the northwest by the Cross Levee, which is about $\frac{1}{2}$ mile in length; and on the north by $\frac{1}{2}$ mile of the Illinois Central embankment. At the time of the washout mentioned, the other two railroads at that point were under water, and the only means of communication that Cairo then had was by wire and by

boat, the city being surrounded by water. The levees successfully resisted the flood, and demonstrated the value of levees as a protection from high water.

The Illinois Central Railroad approaches Cairo from the north on a tangent, which for 6 miles is level, at a height of 54 feet above low-water mark, and connects with the North Levee or Illinois Central embankment, already mentioned, at its junction with the Cross Levee. The track at this point curves to the east through a quarter circle, and strikes a short tangent, which lies nearly east and west. From this tangent, the road curves to the south through nearly another quadrant, and passes down on the Ohio Levee to the passenger depot, some 2 miles distant. About parallel with and just south of this east and west tangent, and extending easterly across the river, is the location of the new bridge.

In 1886 a bill came before congress to authorize the construction of a bridge over the Ohio River at or near Cairo, Illinois. The bill provided for a bridge 35 feet above high water, if of continuous spans, and 15 feet if with a draw span. It also provided for the usual surveys and maps to be submitted to the secretary of war, showing the location and velocity of the river currents, the topography of both shores for a mile each way from the bridge site, and the shore lines at high water, low water and at a medium stage; also for a contour map, showing the bottom of the river for ½ mile above and ¼ mile below the bridge site. An examination of the proposed location, by a board of engineers, was also provided for.

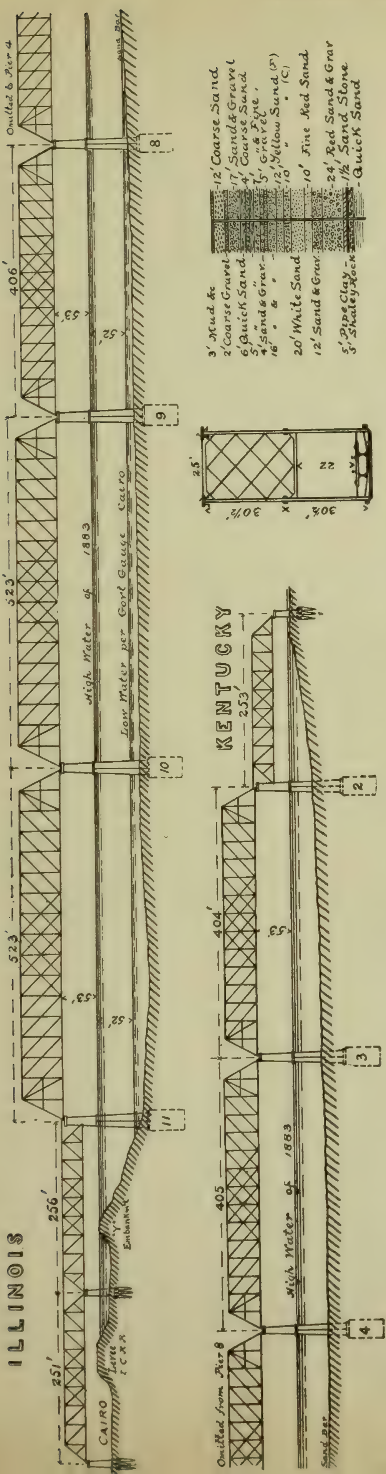
The bill as proposed was opposed by the river interests, on the grounds that at times of high water, the larger craft could not pass under a bridge 35 or even 45 feet above high water line, and that the bridge should be built 53 feet above high water. It was also asserted that it was difficult to pilot large tows of coal, etc., between the piers, even of long spans, without injury and sometimes even loss of the cargo. In substantiation of the first point, the Thos. Sherlock, a Cincinnati boat, was said to be 57 feet between the water line and top of pilot-house; and in illustration of the second, the loss of a tow of 160,000 tons of coal at the Henderson bridge, during a late high water, was recently cited, the tow having struck one of the piers of the channel span. It was also held, that while the general river traffic might have declined in recent years, still the coal traffic, down the Ohio to points south of Cairo, was steadily increasing; and had, in 1885, reached the magnitude of 4 million tons annually. On the other hand, it was shown that the Illinois Central Railroad Co. transferred by boat in 1884 at Cairo 61,723 loaded freight cars and 8,000 passenger cars, and that, while the tonnage of Ohio and Mississippi river craft, touching at Cairo, had decreased nearly 500,000 tons, in the four years previous to 1886, the railroad tonnage crossing the river at that point had increased over 200,000 tons during the same time. Also, that there were but 10 boats on the Ohio River that could not pass under a bridge 45 feet above high water, a height which they were willing to accept; and also that, for 18 years previous to that time there had been on an average only 12 days in each year when those boats could not have passed under a bridge 45 feet above high water. The increase in expense of building the bridge 53 feet instead of 45 feet above high water, was

estimated at $500,000; which divided among the 10 boats would be an additional expense of $50,000 incurred for each boat, in order that it might pass each year during the 12 days of extreme high water. As a continuous bridge was proposed, the board of engineers recommended to congress that it be built 53 feet above high water.

The surveys to determine the location and velocity of the current of the Ohio River at high water, at a medium stage and at low water, were made in 1886 and '87, by J. M. Healey, Division Engineer, assisted by S. F. Balcom, E J. Steinbeck and L. Thompson. The method pursued was to measure carefully a base line, which was made 1250 feet long, on the railroad embankment at North Cairo; the same base line being used in the surveys made at the three stages of water mentioned. A point was established on the Illinois shore ¾ mile up the river from the bridge site, and a line about at right angles to the current was located across the river by a foresight on the Kentucky shore. From this line, floats marked with red and white flags were started, the first one 700 feet from the Illinois shore. Transits were placed at each end of the base line and with the transit at the upper end of the line, an angle from the base line was laid off; by means of which the float was located the required distance from the given point on the Illinois shore. When the float was in proper position, an all right signal was given and a response made as the float was loosened, at which time both transits noted the angle. At the expiration of each succeeding two minutes the angles were read, locating the positions of the float. These observations were continued until the float had passed down the river at least ½ mile below the bridge site. This process was then repeated for other floats, each succeeding float being started 700 feet farther away from the Illinois shore than the float just preceding. This work was continued until a line of floats extending across the whole width of the river had been started and their course located for a distance of 1¼ miles.

The results of the surveys showed the currents of the river to have practically the same direction at all three stages of water mentioned. This is a very favorable point; for at some bridges the direction of the current at high water varies as much as 45° from the direction of the current at low water. The velocity of the current at high water was found to be about 4 miles per hour, that at a medium stage to be almost as much, and at low water the current was about 3½ miles per hour

The stage of water in the Mississippi River affects the velocity of the Ohio River current for some miles above the junction of the rivers. During the high water of 1884, although the water at Paducah was some 3 feet higher than during the high water of the previous year, it did not reach the stage of water at Cairo, by 4 inches, that it did in 1883. This was caused by the Mississippi River being low at that time, allowing the water to escape faster than at points up the Ohio River. It was so much lower that the water from the Ohio set back up the Mississippi for some miles; and drift-wood, etc , could be seen floating up the Mississippi River next to the Illinois shore. The reverse happens at times, during high water in the Mississippi; and at such times the Ohio River current is retarded.



The topographical survey was made in November, 1886, by L. T. Moore, Chief Engineer, and J. M. Healey, Division Engineer, assisted by J. McIntyre and S. F. Balcom. The soundings were also taken at that time and the topographical maps made subsequently in the Chicago draughting office. The first step in this survey was to locate the west end of the bridge on the Illinois shore, and to extend the line across the river as nearly at right angles to the current as practicable. This was then produced on each side of the river and curves were run in to form the approaches that connect the bridge line with the main track. Base lines at right angles to the bridge line were then run, on each side of the river; and points on these lines were marked ½ mile apart, beginning at the bridge line. Corresponding points on each side of the river were connected, making 4 lines parallel with the bridge line, and ½ mile apart—two of them being above, and two below, the bridge site. On these lines levels were taken on shore and soundings in the river, and the parallel lines were connected by a line of levels. From the base lines, angles were laid off with a transit; and in that way soundings were directed and located. Measurements were also taken from the base lines, to locate the shore lines of low and high water. The stage of water at the time the survey was made was about 4 feet above low-water mark, on the Cairo government gauge.

In accordance with the bill passed by congress, a contract was made with the Union Bridge Company for a bridge about 4650 feet in length and 53 feet above high-water mark of 1883, which was 52.2 feet above low-water mark on Cairo gauge. The bridge is to have 9 through spans, 2 of them to be 523 feet between center of piers, and the remaining 7 spans about 405 feet each; also one deck span of 253 feet on the Kentucky side, and two deck spans of about the same length on the Illinois side. Mr. George S. Morison is Chief Engineer of the

bridge, and Mr A. Noble is Resident Engineer in charge of the work. Messrs. Anderson and Barr are putting in the foundation work, Mr. Barr being in immediate charge.

During the summer of 1887, work on the caissons began; they were framed near the Transfer Incline on the Illinois side, and when completed were launched and towed to position, about 1 mile up the river. The name caisson applies to the framework forming the working chamber of the foundation and is 16 feet in height.

The caissons* for the foundations of the 3 channel piers are 70 feet long and 30 feet wide. They consist of an outside wall of 12x12 inch timbers, of yellow pine, laid one on top of another and firmly bolted and fastened together. On the outside of this 12-inch wall, a 3-inch course of oak plank is spiked, being placed diagonally; and this course of planking covered by another, placed vertically. The corners are rounded and covered by curved plates of boiler iron. At the bottom, a cutting edge is formed by a vertical plate of boiler iron, which is riveted to a horizontal plate that is securely fastened to the lower side of the side walls. These two plates are firmly braced and stiffened at short intervals on the inside, by angle plates and braces, riveted to each plate. This cutting edge extends around the caisson, and is rounded at the corners. Just above the cutting edge, an inner wall is started; which springs from the outer wall, at an angle of 45 degrees. This wall is formed of 17-inch square timbers, which extend clear across, and the ends are framed into the outer walls. As these inner walls stand at an angle, their intersection with each other, at the corners of the working chamber, forms a very complicated joint, as the timbers have to cross each other and extend on to the outer walls. For this reason, the timbers in these walls are made 17 inches square, which, standing at an angle, makes their face occupy a vertical distance of 12 inches, and so correspond with the timbers in the outer walls. This inner wall is carried up until a vertical height of 6 feet above the top of the cutting edge is reached, when a timber ceiling is made over the top of the working chamber, and this course of timber covered below with oak plank, which have the joints or seams tightly calked to prevent the escape of compressed air. After the caisson has been towed into place and anchored to piles, the triangular space between the outer and inner walls mentioned is filled with concrete The outer wall is continued up and a crib work is formed by 3 rows of timbers lengthwise and 7 rows crosswise, placed in alternate layers, one on top of the other, and bolted where they cross. The ends of these timbers are framed into the side walls, and all open spaces in the crib work are filled with concrete. In constructing the crib work, pipes are provided which pass into the working chamber to supply water, compressed air, etc. A shaft with an air-lock is also provided; these are made of boiler iron and are built into the crib work, and remain there. The air-lock has 2 doors—one leading into a shaft that passes into the working chamber, the other opening into a shaft that leads to the top of the works. Other forms of air-locks have been used on other works. In some cases the air-lock has been placed

*A number of blue prints of the caissons, piers, etc., showing construction and progress, are being prepared and will be ready for distribution soon.

in the working chamber, and in others it was placed on top of the works; the latter method required that the air-lock be frequently raised, as the work progressed.

The method of sinking the caisson is to keep the working chamber filled with compressed air, which prevents the water from entering. A stream of water is forced through a large pipe that enters the working chamber on one side, crosses the chamber and passes out again from the other side, and up to the top of the work where it is discharged. Connected with this stream of water is a Morison sand pump, a modification of the Eads sand pump. The stream of water being pumped through the pipe mentioned, forms a suction that by means of the sand-pump carries out the sand, which by means of a jet of water has been worked up into a thin mortar. In this way the excavation is made, and the weight of the caisson is usually sufficient to lower it. However, in the early stages of the work, it sometimes happens that the weight is not sufficient to overcome the lifting pressure of the compressed air, etc. At such times the pressure is lowered, which usually accomplishes the lowering of the caisson; but reducing the pressure allows the water to come in, so that the men at such times may be up to their knees in water.

Some queer effects are produced by compressed air; at a pressure of 30 or 40 pounds per square inch, a square or flat bottle that has been filled with ordinary air and tightly corked, will be crushed. A round bottle might be able to stand the pressure, but the flat sides of a square bottle can not do so.

The method of entering the caisson, is to pass down the shaft from above, enter the air-lock and securely fasten the door; then by means of a valve, allow the condensed air from below to enter, which it does with a loud hissing sound. The change from the ordinary atmosphere is immediately felt by a pressure on the ear drums and a feeling as if the ears were stopped up. This becomes stronger as the pressure becomes greater, but is only felt while the transition is being made from one atmosphere to another, and can usually be relieved by swallowing. Cases have been known where the ear drums were seriously injured. Some experience sharp pains in the ears; but as the working chamber is entered, this trouble is relieved, as the air in the lungs and head is then of the same density as the surrounding atmosphere. The same trouble is again experienced in passing through the air lock on the way out. Another odd freak that gives an idea of the pressure that compressed air has, is that one can not whistle in the caisson after it has reached any considerable depth. As the caisson is lowered, a stronger pressure is required; and at low depths, men can work but a few hours at a time without risk of injury. A peculiar fever and an ailment called the bends, somewhat similar to rheumatism, is sometimes brought on by working under a high pressure for too great a length of time.

The large amount of oxygen in the air at high pressure makes an increased danger from fire. This is illustrated by the fact that at 30 pounds pressure a person can not hold a lighted candle in each hand and blow out the flames of both of them; for after blowing the first one out, it will ignite again, although 2 feet away, before the second flame can be blown

out. The Brooklyn caisson of the East River bridge caught fire and the works had to be flooded before the fire could be extinguished. One of the caissons of the Bismarck bridge also caught fire. The caissons at Cairo are lighted with incandescent electric lights.

The crib work above the caisson in the 3 channel piers is 34 feet in height. This, with the 16 feet of caisson, gives a foundation 50 feet in depth. On this concrete foundation the stonework of the piers is placed. In the 3 channel piers the lower course of stonework is 26 feet wide and 66 feet long. The ends of the piers are in the form of pointed arches, and at the base are formed with 20 feet radii. The stone work of the piers is being done by Messrs. Loss and Wilson, with Mr. Loss in charge. The stone used comes from Bedford, Indiana, and is a light colored limestone that can be quarried in almost any thickness, and is easily worked. It hardens on exposure, and in local structures shows indications of durability. It was also used in the Henderson bridge It is cut at the quarries to the dimensions furnished by the Resident Engineer, a plan of each course being made. The courses are from 24 to 36 inches in thickness, and the backing is made of the same thickness and quality of stone. Broken joints are required, but the edges of the stones in the backing are not required to be dressed. The granite used comes from New Hampshire, and is only used in the cut-water or end stones of the courses, between high- and low-water lines, at the up-stream eud of the piers.

The stone used for concrete is a very hard, dark colored limestone, quarried at the Ullin Lime Kilns, about 22 miles north of Cairo, and is broken with a stone crusher. The concrete used in the caisson and crib work is put through a concrete mixer, which is a revolving box made of plates of boiler iron riveted at the edges. It has a square cross section and is 3 or 4 times as long as it is wide. It is operated by steam, and the stone, sand, cement and water pass in at one end and out at the other, falling into a hoisting tub. It is a comparatively recent invention, and this is one of the first bridges, in this country, at which it has been used. The concrete over the working chamber is made of 2 parts of stone, 2 of sand, and 1 of cement. That in the crib work is made of 4 parts of stone, 2 of sand, and 1 of cement. When the caisson has been sunk to the required depth, the working chamber is made tight around the edges, and over the bottom, with a coating of 3 parts of sand to 1 of cement, and is then filled with concrete made of 3 parts of stone, 2 of sand and 1 of cement.

The cement used is mainly Alsen's Portland Cement for bottom, sides, etc., of caisson and for laying face stones in the piers. Louisville cement is used for backing in piers, concrete in crib work and caisson, etc.; except in freezing weather, when Portland cement is used. Mortar joints, and beds of face stones, are made ½ inch; and the mortar is made of 2 parts of sand to 1 of cement for face stones; and 3 parts of sand to 1 of cement for backing.

Each car-load of cement received is tested, and a record is kept of the tests, showing the per cent. that fails to pass the No. 50 and No. 100 sieves; also the tensile strength one week after mixing. The method of making the latter test is to mix samples of the cement until a fair average

is obtained, then 10 briquettes are moulded of the standard form, having a cross-section of one square inch. They are then allowed to stand, covered with a wet cloth, for 24 hours, then are immersed in water 6 days; at the end of that time they are placed in the testing machine and the breaking strain ascertained.

Louisville cement is required to stand a tensile strain of 75 pounds in winter and 100 pounds in summer. About 5 per cent of the Louisville cement received at Cairo has been rejected. Portland cement seldom shows a tensile strength less than 400 pounds.

It was the intention to have the 3 channel piers so far completed, that the usual high water of January and February would not delay the completion of those piers. The January rise, however, being quite rapid, the third foundation was submerged, so that very little more can be done to it until the water goes down in the spring or summer. The foundation of the pier next to the Illinois shore was sunk 75 feet below low water and the masonry completed up to high-water line previous to Jan. 1st, 1888. The foundation of the second pier was sunk to the same depth, and the stone work kept ahead of the rising water in the river. When not delayed, these foundations were lowered at an average rate of about 2 feet per day.

Some trouble was experienced from scouring, next to the foundation that is under water. At one time, the up stream end of the caisson was 14 feet lower than the opposite end and the excavation made by the current was still 2 feet lower. At that time work on the cribbing was abandoned and the caisson sunk into position again. Should the scouring continue, so that the foundation is carried so far out of place that it can not be shifted into position again, it will present a serious obstacle and possibly necessitate a change in the location of the pier and in the length of the bridge spans to correspond.

At the end of the coming season a large portion of the foundation work will probably be complete, and work on the steel superstructure well under way, which with work on the approaches will furnish much interesting matter for observation and study to those interested in that line of engineering.

DISCUSSION.

Mr. Hansel.—Have they the pier righted yet?

Mr. Balcom.—Very nearly so, and it is very little out of position.

Mr. Clark (Springfield)—It would be well to test different specimens to find the relative strength of different cements.

Mr. Balcom.—Such tests are being made. There is one man employed for the especial purpose of testing the cements.

Mr. Clark (Springfield).—Tests have been made which show that some of the weaker cements increase in strength much more rapidly than Portland cement. Now, may not such cements in time become as strong as the Portland?

Mr. Balcom.—I think that may be so. There is one sample which

I have of Louisville that after 3 months was double the strength of 7 day samples. I do not know, however, whether it was the same brand.

Mr. Baker.—As I remember, Rosendale gains all its increase of strength in six months, while Portland does not cease to increase in strength for a much longer period. At the end of one month Portland has a tensile strength of 250 pounds per square inch, while Rosendale has a strength of only 100 pounds.

Mr. Balcom.—From tests made by the American Society of Civil Engineers, we have strength of American natural cements in 1 day, 40 to 80 pounds; 1 week, 100 pounds; 1 month, 100 to 150 pounds; 1 year, 300 to 400 pounds; and strengths of Portland cements, 1 day, 100 to 140 pounds; 1 week, 250 to 550 pounds; 1 month, 350 to 700 pounds; and 1 year, 450 to 800 pounds.

Mr. Talbot.—Did they make tests at Cairo of cements mixed with sand? I have found cements that gave high tests when neat, but when mixed with sand the results were unusually low, showing that the result of neat tests can not always be trusted.

Mr. Balcom.—They did.

LAYING OUT TOWNS, AND THE VALUE OF PROPER MONUMENTS.

By T. S. McCLANAHAN, of Monmouth.

When asked by a member of your executive board to prepare a paper, I felt reluctant to consent, but concluded that my individual responsibility to the society would not allow a refusal.

In the laying out of towns whether large or small, if the town is to cover a quarter-section of land, I would first find all of the quarter-section corners so there would be no doubt of their correct position. I should not allow either time or expense to cut any figure in the matter of settling this one important question. My next business would be to plant at each of said four corners a stone 3 feet in length with the top end dressed to 8 inches square and with a 1-inch hole drilled in the exact center of top 6 inches deep; this top to be left 4 inches above surface of ground.

My next business would be to find if any of the lines on said quarter are true meridians. If not, I should determine where either

the public square or the crossing of the two principal streets would be. Here in this center I would set a monument of the kind described. From this center stone I would extend a line north and south to limits, said line being the true meridian, and also a line east and west to limits. I should reverse my instrument, whether compass or transit, and test these angles until I knew they were correct. If these two principal streets are to be 100 feet wide, I would next measure off an exact square, with sides of 100 feet, the hole in above named stone to be the center of said square, and the outside lines of said square to be exact parallels to first two lines. When found, I would mark them by driving a 2-inch round iron rod, 3 feet long and having a × cut in top, level with surface of the ground; said lines of cross to be as near as practicable in line with diagonal lines of square. I would now stake off into blocks the side lines of the two principal streets. In so doing, I would again test the accuracy of my instrument and angles by setting my instrument over one of these iron corners and extending lines from these points at right angles, which should strike 50 feet from the points first set on the limits. When they do so, I run and set the block, lot and alley corners on both sides of these two principal streets to the limits. Next I place the two stakes set at the ends of the two streets on the boundary line of the quarter-section. I then run in and place on the outside lines the block, lot and alley corners corresponding to the ones on the two streets already run. If the alleys are to run east and west, I move my instrument one block east or west, and line and chain to a flagman stationed at the corresponding stake on the opposite boundary, continuing to do so until all has been laid out into lots and blocks. I then test the chaining of all outside lines. When I find it to be correct I set my transit on a lot or block corner on principal street, station a flagman on the corresponding stake on the north or south side, set a compass on the first stake north of this street and a flagman on the corresponding corner on the boundary line. Then the stake-man moves his stake until it comes in line with both instruments. The compass and its flagman move for every stake; the transit and its flagman remain stationary for the line through. When practicable, I would leave all surplus or deficiency in a street or alley. Where I can not do so I would measure last lot of each block facing outside line and leave surplus or minus in them, being very careful not only in the survey but in the plat and record throughout to complete the job, I would set for monuments stones such as I have described, one at each of the north corners of the north blocks adjoining the principal north and south street, two at the south end of the same street, and two at the ends of the principal east and west street. At all other block corners, I would drive an iron rod $1\frac{1}{2}$ inches in diameter and 3 feet long with cross cut on top, to be set 10 inches diagonally from block corner and so that one of the cross lines may line to corner and driven to surface of ground. This would finish the work.

For any town of less area I should be just as particular in locating the quarter-section and in finding the exact location of the piece to be laid out, and should want to mark the nearest quarter corners as well as in the preceding. I would mark the four corners and proceed in every respect in the same manner as before. In either case, I would have the monuments and alignments so solid and exact that any one could find them, or so they would never be lost and need finding.

Coming to the second topic, a monument is a stone or other permanent object serving to limit or to mark a boundary. As I understand the law in regard to lands, monuments are over and above all other evidence. Courses, distances, and even area may fail, but a monument found and identified never fails. Permit me here by way of illustration to show the value of permanent monuments by relating an experience in a survey in 1866. I was called upon to subdivide Secs. 31, 32 and 33, T. 8 N., R. 3 W. After extending the south line of T. 8 N., R. 3, through from southeast corner of same, I found what was supposed to be the corners to Secs. 34 and 35 and 33 and 34, but when I extended my line to the southwest corner of Sec. 31, I found myself some 400 links south of point accepted by former surveyor for the corner to T. 7 and 8 N., R. 3 W., and 7 and 8 N., R. 4 W. As this was the county corner for the counties of Warren, Henderson and McDonough, I felt somewhat backward in finishing my work until I had help to find corner. The counties each offered to help by their county surveyors. We as said surveyors met and proceeded to establish said corner, and after having closely examined the plats and field notes for the four towns, we found that we had an anomaly in surveying to deal with. If we could have found a well identified government corner, either with witness trees or a monument, it would have been easy to settle the matter. Not finding this, we commenced a survey, and after running 36 miles of line and closely examining every point, we finally set the corner 2.46 chains southeast of the corner accepted by the former surveyor, setting a large and well marked stone. The three counties accepted the survey and adopted this corner as the county corner.

A party in Henderson county objected to the party north of him moving down on what was called the new county line, and a lawsuit was commenced, which lasted seven years and cost $7000.00 and had eighteen different surveyors, three at a time, to test the new corner, all agreeing with new corner.

Now if we could have found a monument at the corner it would have saved all this $7000.00 and the bad feeling growing out of the suit. Therefore I heartily concur in the recommendation of Mr. J. S. Burt, of Henry, in his paper last winter. Let the State adopt a pattern and have the convicts work them out; have a law that nothing else can be used. They will not cost $7000.00, and would stop all litigation. In order that there may be no doubt in regard to the monument being the proper one, the stones should all be of some

particular pattern and should be used at least for section and quarter-section corners. The section corner stone should be at least 6 inches square, the quarter-section 5 inches square, and neither of them less than $2\frac{1}{2}$ feet long.

DISCUSSION.

Mr. Hansel.—I have examined county records in many towns and cities; Mr. McClanahan has mapped out the ideal town I have been looking for. All sections and divisions should be numbered on the maps. Stones ought to be used as a monument to show that corners have been established, even if they are not done so correctly.

Mr. Mead.—This has been quite a prominent question in Rockford. Three years ago I was asked to look up the monuments of the town. I found them very much mixed up. When the town was laid out land was very cheap and surveys made very carelessly. In some localities an excess of 1 to 3 feet was found. In some cases monuments were recorded but never put in place. Some of the monuments were small pieces of limestone or small boulders simply laid on top of the ground. In making a re-survey there was in many places no monuments to run from. Where a street was recorded as straight and was defined by fences, I established several center points from these fences and took an average for the center line of the street. New monuments of iron pins were then put in. In my opinion these are not legal monuments, but it was the best that could be done under the circumstances.

Mr. Chamberlain.—In a Kansas town I found no monuments to speak of. I found 60 feet surplus in a mile. I distributed the surplus and it was allowed to ripen into title by lapse of time.

Mr. Wright.—In Indianapolis, Ind., there were cases of 13 feet error in a block. As often as a change in city engineers was made, there was a change in the lines of property owners. We used a similar course to that of Mr. Mead. The board adopted a certain survey and had the legislature legalize it I advocate the placing of witness stones, as corner stones are dug up when in the center of the street or road.

Mr. Chamberlain.—I am in favor of adopting such surveys as near the truth as possible and then let it ripen into title by lapse of time.

Mr. McClanahan.—At Monmouth the error was legalized by special act.

Mr. Enos.—We cannot get a special act in this state. We may

ripen title as between individuals, but will title ripen against the public for streets? This is a different question. I differ from Mr. McClanahan in that I would establish all outside corners first. I put my monuments underground, using four hard bricks, two placed crosswise on top of the other two, the intersection of lines between bricks marking the corner; on top of these bricks I put a granite stone.

Mr. C. W. Clark.—As a sample of poor surveying I will cite a case that I met with in Missouri. I had occasion to establish corners of lots and found that the company had in one case built several cottages on dividing lines between lots, and had sold them to private parties. In another case lots had been sold, one-half the depth of which projected over a bluff bank into a river. In another place one side of a street was defined by a row of large buildings; the opposite side of the street was 18 inches from the face of a building in one place where they had supposed it to be 8 or 10 feet.

Mr. McClanahan.—I prefer to have the monuments above ground, and would like to have it a criminal offense for any one to remove them.

Mr. Chamberlain.—Two witness stones are better than putting the monument under ground or than leaving above ground at the center of street.

Mr. Braucher.—I prefer to have mark at center of street rather than at corners.

NOTE ON MAGNETIC DECLINATION AS DEPENDENT UPON THE INSTRUMENT.

By Prof. IRA O. BAKER, of Champaign.

The surveyor is sometimes compelled for one reason or another to survey lines by the magnetic compass; this is true even in localities where the land is surveyed according to the United States system, and it is the rule in other localities. Two instruments will seldom give the same declination, even though read on the same line at the same time by the same person. Since this note is only to present a few facts, it is not necessary to repeat the reason for this difference.*

In the course of the ordinary class instruction, the writer had his class in land surveying, consisting of eleven members, determine the magnetic declination by observing upon a true meridian with the following instruments; the instruments were read at the same time, each man observing each instrument. The instruments were in *perfect* working condition in every particular. The results show the mean declination with the probable error of each:

Yellow Transit, - -	4° 27′ ± 2.8′
Black " - -	5° 42′ ± 1.′5′
Mining " - - -	4° 33′ ± 1.6′
Black compass - -	4° 40′ ± 1.6′
Yellow " - - -	4° 51′ ± 1.2′
Old " - -	4° 37′ ± 1.2′
Pocket " (4 obs.) -	3° 32′ ± 4.5′

Mean declination by first six instruments above = 4° 48⅓′. The pocket compass is so made that the wind acted upon the needle, and hence only four reliable observations were obtained. Notice that the greatest difference is 1° 15′.

As far as can be determined with so few observations, the probable error of the declination as found by a single reading with an instrument is nearly 17′; that is, if both instruments are in good working condition and skillfully used, we may reasonably expect a difference of 17′ (26 ft. in a mile) in the bearing of a line as read by the two instruments at the same time and place. This source of error is generally neglected; frequently it is impossible to do otherwise, but it should be continually borne in mind as a *possible* source of error.

*For the reasons, see an article by the author of this in Engineering News, Vol. 14, p. 277.

THE TRUE EXTERIOR BOUNDARY OF TOWNSHIPS.

By Z. A. ENOS, of Springfield.*

The question presented for consideration is, whether the exterior boundary line of a township as it was first run, or that line as modified by the subdivisional surveyed lines and corners, is to be regarded as the true township boundary line. In the discussion of this question thus far, it will be perceived that the advocates for both lines regard the 2d section of the act of congress of February 11th, 1805, as the law that determines the question; but they differ as to the proper construction that is to be given to that section. The legal question being thus narrowed, I propose to consider the section carefully, as also the arguments that have been advanced to sustain the exterior boundary line survey, and try, by a clear statement of the law, facts and reasons, to make it as plain to others as it appears to myself that the modified, or subdivisional survey line, is the true line. And here, as preliminary to my argument, I will state that, as a principle of legal construction, the courts regard the provisions of all statutory laws as either mandatory or directory, holding the mandatory enactments to be imperative in their provisions, being commands that cannot legally be disobeyed or disregarded, while the directory are treated as discretionary or permissive in character. The former are usually indicated by the words shall, shall be or must in connection with the act or thing that is specified to be done or refrained from doing; the latter by may or can. Now the 2d section of the act of 1805 begins with what I understand to be a mandatory provision in the following words: "Sec. 2. And be it further enacted, that the boundaries and contents of the several sections and quarter sections of the lands of the United States *shall be* ascertained in conformity with the following principles, any act or acts to the contrary notwithstanding," thus positively commanding that certain principles or rules shall be used to ascertain or determine boundary and contents, and as a necessary consequence, precluding a resort to any other means for that purpose. But here, at the outset, it will be observed that the act provides only for ascertaining the boundaries of the sections, half sections and quarter sections, and that no mention or allusion is made to the boundaries of townships, range, meridian or base lines as such, and that they have no legal status or recognition by this 2d section other than is to be deduced from the fact that they are composed or made up of section or subdivisional section lines; so that by virtue of this section no legal distinction between the exterior boundary section lines and the interior subdivisional section lines of the township

exist, both being on a perfect equality, and resting for their legal character upon the fact that they are the boundaries of the sections, nothing more or less.

It then being clear that it is only the boundaries of sections, half sections and quarter sections, as such, to which the 2d section applies, the next inquiry is, what are the principles in conformity with which it declares these boundaries shall be ascertained? It has stated them numerically and placed them in their well established judicial order of procedure, which gives corner monuments of boundary the highest rank, and they are as follows:

"1st. All the corners marked in the surveys, returned by the Surveyor-General, or by the surveyor of the land south of the State of Tennessee, respectively, shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate; and the corners of half and quarter sections not marked on said surveys shall be placed, as nearly as possible, equidistant from those two corners which stand on the same line."

Now these corners so returned, consisting almost exclusively of posts in mounds, marked stones and witness posts, were made by the U. S. deputy surveyors, under the instructions of the Surveyor-General, to designate or mark the corner boundaries of the sections, half sections and quarter sections of the U. S. land surveys, as the same were surveyed by them, and being returned as such corners by the Surveyor-General in pursuance of law, in consequence of such return and by virtue of the 2d section, they became the fixed legal monuments of corner boundary, and according to all judicial decisions, the highest grade of evidence of the same; and in the mandatory words of the act, they "shall be established as the proper corners of sections or subdivision of sections which they were intended to designate," and that, too, without any exception, qualification, restriction or reservation in regard to when or how they were made—whether in the exterior survey line or the subdivisional survey line. They all stand upon the same level and on a perfect equality before the law, for the act says ALL the corners marked in the surveys returned shall be established as the proper corners, and this use of the adjective all precludes the idea of any exception or distinction whatever; and it is a fact that should be noted, that this use of the word all is made in connection with any other enunciated principle or substantive fact mentioned in the 2d section. And here I wish to state, and desire it should be carefully considered, that in the question at issue there is not necessarily, nor can there be properly, any conflict between the corners of the two surveys, for it is not a question as to which of two corners is the proper or correct corner of a section, but the issue is between the line of one survey, as against the corner and line of another survey. A further consideration of this point will, however, be deferred until after examining the next or 2d clause of the 2d section. It reads as follows:

"2d. The boundary lines, actually run and marked in the sur-

veys returned by the Surveyor-General or by the surveyor of land south of the State of Tennessee, respectively, *shall be* established as the proper boundary lines of the sections or subdivisions for which they were intended; and the length of such lines, as returned by either of the surveyors aforesaid, shall be held and considered as the true length thereof. And the boundary lines which shall not have been actually run and marked as aforesaid, shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional township, where no such opposite corresponding corners have been or can be fixed, the said boundary lines shall be ascertained by running from the established corners due north and south or east and west lines, as the case may be, to the watercourse, Indian boundary line, or other external boundary of such fractional township."

Before proceeding further in the discussion, it will be well to consider what meaning is to be attached to certain words that are used in this 2d section. For instance, what is meant by the word "run" as used in the sentence. "The boundary lines actually run and marked in the surveys returned by the Surveyor General," etc.? I take the word to be the equivalent of the word surveyed, or of compassed and chained (as the law required that the lines should be), and in that sense shall use the word. Then, again, the word "marked," in the same and other sentences. This word is used apparently with very different meanings in different acts of congress. For instance, one act required the lines to be marked by chaps on the trees, another that all lines should be plainly marked upon trees, the word marked meaning hacked or blazed. Again, the corners are required to be marked at the distance of every mile or half mile, presumably meaning that the corners should be made at every mile and half mile. But the word as used in section 2, I am now inclined to think, is synonymous with the words designated, shown, or indicated, for by their very character the surveys could not by any possibility be returned, and only descriptions of them could be, such descriptions as the field notes and plats would give (and which are commonly designated as the surveys). That, therefore, the words "mark in (or on) the surveys returned" (both prepositions being used in different parts of the section), would be in effect the same as if the words "shown," "indicated" or "designated in (or on) the plats and field notes returned," etc., were substituted therefor; and the whole sentence and the other similar sentences are to be understood substantially as if the wording was, "That the corners, or the boundary lines actually surveyed and shown in or on the plats and field notes returned by the Surveyor-General," etc.

And then the word *returned;* what meaning is to be attached to it? To whom were the surveys to be returned; by whom and for what purpose were they to be returned—in fact what constituted the returns here mentioned? A distinct understanding of what is meant by the return of the surveys, or as it is usually expressed, "the *re-*

turns," will go far towards determining the question in controversy. The act of February 11th, 1805, gives no explanation of the meaning of the words "the *surveys returned*," and we have to go back to previous legislation for the information. In the ordinance of 1785, entitled "An ordinance for ascertaining the mode of disposing of lands in the western territory," is a provision that "as soon as seven ranges of townships and fractional parts of townships shall have been surveyed, the geographer (the officer authorized to superintend the surveys) shall transmit PLATS thereof to the board of treasury, who shall record the same, with the report, in well bound books to be kept for that purpose; and the geographer shall make similar *returns*, from time to time, of every seven ranges, as they may be surveyed." The act of congress of May 18th, 1796, for the sale of the lands of the United States in the territory northwest of the river Ohio and above the mouth of Kentucky river, created the office of Surveyor-General and defined his duties, and also provided for the places where and the persons who were to make the sales. Among the various provisions therein relating to the survey of the lands is the following: "Every surveyor (alluding to the deputy surveyors) shall note in his field book the true situation of all mines, salt licks, salt springs and all the mill seats, which shall come to his knowledge; all watercourses over which the line he runs shall pass; and also the quality of the lands. These field books shall be returned to the Surveyor-General, who shall thereupon cause a description of the whole lands surveyed to be made out and *transmitted* to the officers who may superintend the sales. He shall also cause a fair *plat* to be made of the townships and fractional parts of townships contained in the said lands, describing the subdivisions thereof, and the marks of the corners. This plat shall be recorded in books to be kept for that purpose; a copy thereof shall be kept open at the Surveyor-General's office for public information, and other copies sent to the places of sale, and to the Secretary of the Treasury." The act of May 13th, 1800, amendatory of the act of May 18th, 1796, provided for four land officers for the sale of the lands of the United States under the direction of officers called Registers of the Land Office, and also provided that it should be the duty of the Surveyor-General to prepare and transmit to the Registers of the several land offices *general plats* of the lands directed to be sold, and also forward copies of each of said plats to the Secretary of the Treasury. And the act of March 26th, 1804, provided that the powers vested in, and the duties required by law of the Surveyor-General, should be extended over all the public lands of the United States north of the river Ohio and east of the Mississippi, and also provided additional places and officers for the sale of the lands.

From these acts it appears that the plats and notes sent by the Surveyor-General to the land offices where, and in accordance with which the lands were to be sold, and the copies of the same forwarded by him to the general land office at Washington, constitute the re-

turns specified in the act of February 11th, 1805. And this view as to what is meant by "the returns," is sustained by the construction that the U. S. land department has given to them, as will be seen by an extract from a communication of the Commissioner of the General Land Office to the Surveyor-General, St. Louis, Mo., of date April 9th, 1838, as follows: "The law makes it the duty of the Surveyor-General to *return* the plats of surveys to *this office* and to the *district offices;* and likewise *make his action final as regards* the quantities and *boundaries*, etc., so *returned*."

These returned plats being thus intended to show the boundaries, contents and character of the tracts of land authorized by the law to be sold or entered as specified in the act of 1805 and previous acts, viz.: sections, half sections and quarter sections, they could not, therefore, possibly have been skeleton township plats, but full and complete plats of such townships, with all sections, half sections and quarter sections marked thereon, with the lengths of lines and intersectional fallings, watercourses, mill sites, and other particulars as to the nature and character of the lands as is specified and required by the act of 1796 and the instructions from the land office at Washington; and the requirements were, as the act states, for "public information," so that purchasers should have full knowledge of every fact in relation to the lands and surveys that was known to the Government or its agents. And that such were these returns, the books of plats (or plat books, as they are called) of every land district will fully attest. These returns specified in the act of 1805, were the final requisites to give legal character to the surveys and establish the corners and boundary lines as the proper corners and lines of the sections or subdivisions of sections; and the returns being of the whole townships, including subdivisions, etc., as *entireties* or *units*, consequently the act took effect and force upon every corner and line at the same moment of time; and under such returns there cannot possibly be any question as to the priority of one survey over another, or the superseding of one survey by the other, for each stands on a perfect equality—corner with corner, and line with line.

Having carefully considered the wording of the 2d section so far at least as it *is applicable* to the point under discussion, I will now endeavor to apply the principles of that section to deciding the question in dispute. The question being, in a case of conflict between the survey of the exterior township boundary line and the subdivisional survey line and corner, which shall yield? This involves but the two principles, the corners marked in the surveys returned, and the boundary lines actually run and marked in the survey returned, etc., which this section says shall be established as the proper corners and proper boundary lines of the sections which they were intended to designate.

Now each of these lines was actually run and marked in the surveys returned by the Surveyor-General, and each by the principle of the 2d clause of the 2d section of the act of 1805, is declared to be

the proper boundary line of the sections which it was intended to designate, neither having any precedence over the other under or by virtue of this clause, and yet the two lines are in direct conflict. Were the principle embodied in this 2d clause the only principle that the 2d section declares shall ascertain boundary, there might be such a question as would justify the resort to the intentions of the U. S. deputies in running the lines, the prirority of survey, etc. But this is not the case; for as I have already shown, the 1st clause of the 2d section in relation to boundaries declares that the corners marked in the surveys returned by the Surveyor-General shall be established as the proper corners of the sections, etc., which they were intended to designate, and this 2d section further declares that the boundaries shall be ascertained by these *principles* (which must of course preclude a resort to any other principle). Then, if tested by these principles for ascertaining boundary, we have the two principles of the act, and the only ones therein enumerated that are applicable to determine the question, namely, returned corners and lines, and of these principles the exterior survey has one to sustain it and but one, and that the weaker principle, while the subdivisional survey has both. The question having to be determined by this 2d section and the preponderance of principle, both in number and weight, being so greatly on the side of the subdivisional survey, it does therefore appear to me that the majority must control, and the one have to yield to the two. And such a construction I cannot for a moment doubt the courts would give to this act, which not only prescribes, but at the same time excludes the application of any other principles. Even on the general principles of construction of deeds, independent of the provisions of this 2d section, I am satisfied a court would not, in order to sustain one line, set aside another line and a corner monument, both of which support and confirm each other. For the courts have ever regarded corner monuments as of a higher grade of evidence than lines, and in a conflict between the two calls hold that the lines must give way and go to the corners. And this distinction made by the courts between lines and corners arises out of their general nature and character, etc.; a line being seldom aught but an imaginary thing, having but one of the properties of dimensions, viz., length, and is therefore intangible to the sense of feeling or sight; while a corner generally has all the properties of dimensions, being usually evidenced by a stone or some substantial monument, and is therefore perceptible to the senses of sight and feeling of men, and they are presumed to take note of the same.

Having thus presented the law, the facts and the reasons for my belief that the modified line is the true line, I will now proceed to consider the arguments advanced in favor of the exterior survey line. They are set forth by its ablest advocate in the following words:

"My first reason is that I think it (the modified line) is contrary to the United States law. Section 2, paragraph 2d of the act of February 11, 1805, says: 'The boundary lines *actually run and*

marked in the surveys returned by the Surveyor-General or by the surveyor of the lands south of the Tennessee, respectively, *shall be established as the proper boundary lines* of the sections or subdivisions *for which they were intended*,' etc. Now the only lines which were actually run and marked along the township and range lines intended to be boundary lines of the townships and sections adjacent thereto, were the township and range lines themselves, which were run and marked previous to the subdivisions of the township. No such lines were run from the closing corners for that purpose.

"For the purpose of illustration I will refer to an actual case to be found within a half mile of my residence. The north line of township 3 south, range 9 west, meridian of Michigan, was run and marked in 1825. The township was subdivided in the spring of 1826. The notes of one of the subdivision lines, omitting immaterial portions, read as follows: 'North between sections 2 and 3, 82.02. Intersected N. boundary (post removed), set post at intersection corner to sections 2 and 3.' The adjoining township on the north was subdivided a little later in the same year. The marked trees along the township line and the bearing trees to the corners were still standing, and stood for many years afterward. In starting his line the surveyor found the corner of sections 34 and 35 and ran from it, making the following entry in his field notes: 'Note.—Post, corner to sections 2 and 3, T. 3 S., R. 9 W., is 19 links too far north.' It was evident that the surveyor who set the closing corner never tried to find the standard corner on the township line, as everything was plain except the post itself, and he could not have missed it. Here was a line actually run and marked for the north line of sections 2 and 3 and for the south line of sections 34 and 35. The surveyor who ran the closing line and set the closing corner ran a line which he intended for the west line of section 2 and for the east line of section 3. He set his corner post to define that line; but he did not run and mark lines east and west from that corner intended to be the north boundary of these sections. His instructions did not call for it. It was not in his contract to do it, and he would not have been paid for it if he had done it. And all for the good and sufficient reason that the township boundary was already established, and he had no power or authority from any source to change it. He might find and retrace the old line, but not make a new and different one without special instructions to that effect.

"Now, to deflect the township line away from the line which was actually run and marked for that purpose, to pass it through a corner which was 19 links too far north, where no line was ever run and marked for the township line, seems to me to be contrary to law, to the instructions, and to good common sense."

These quotations present fully the position assumed, with the reasoning in support of it. Let us consider carefully and see if they should override the well settled principle of law which gives to corner boundary monuments the preponderating weight as evidence of

boundary. Now, taking the case presented as to the corners and boundaries of sections 34 and 35 and sections 2 and 3, which is perhaps as strong a case as can be found in favor of that construction of the law, yet I think that case and the arguments can be fairly met and answered.

1st. The claim that inasmuch as the south boundary lines of secs. 34 and 35 were actually run and marked in the surveys as returned by the Surveyor-General, that therefore these section lines are by this 2d section of the act of Feb. 11, 1805, the proper boundary lines, would be unquestionably true if there was no other and conflicting evidence of boundary. But the same law, and for identically the same reasons, declares the conflicting boundary line between sections 2 and 3 to be the proper boundary line of those sections, and it further declares the corner monument returned for sections 2 and 3 to be the proper corner of those sections. Here are three points of evidence, two of the same or an equal second grade and a third of a higher or first grade, and they stand one against two, one second grade against a second and a first grade, or the compassed and chained boundary lines of sections 34 and 35 against the compassed and chained boundary line between sections 2 and 3 and also the returned witness corner for sections 2 and 3. Without any other facts in evidence, there can be no question but that the two points would control the one.

2d. That the south boundary lines of sections 34 and 35 were run by the United States deputy, and returns made by him to the Surveyor-General, before the subdivisional lines between sections 2 and 3 were made and returned. The answer to this is, in short, that the date of the survey or the return to the Surveyor-General, are not legal requirements specified in the act; nor is it in any case the *returns made to the Surveyor General*, but the *returns by the Surveyor General* that establishes the corners and boundaries of the sections and subdivisions of sections as the proper corners and boundaries, according to the act of February 11, 1805; and so the dates of the surveys may be years apart, yet until returned by the Surveyor-General, neither can have any legal existence.

As to the objection that the corner for sections 2 and 3 is void, because the instructions to the subdivision surveyor was to close on the lines of sections 34 and 35, previously run as the township boundary, and he did not, but made the corner in violation of the instructions. If neglect or disregard of instructions will invalidate the returned corners and boundaries, there are few of either that can claim any legal existence. There are in this state thousands of cases, and in my own county there are two whole townships in which the surveyor in sectionizing did not in more than half the cases run through east and west, and place the ½ section corner on true line between and equidistant from the two section corners as required by the instructions, but just run east 40 chains and made a corner. This dis-

obedience of instructions has resulted in some instances in making the east $\frac{1}{2}$ of the section from one to two chains wider than the west $\frac{1}{2}$, and in placing the $\frac{1}{2}$ section corner between 40 and 100 links north of a right line between the section corners. Yet no surveyor or court has ever thought of removing these corners into straight line with and equal distance from the section corners, or of establishing the unsurveyed line between the $\frac{1}{2}$ section corner and the east section corner, other than in pursuance of the act of 1805, legally ascertaining it by running a straight line between those corners; but if a disregard of instructions will invalidate the returned corners and boundaries in the first instance, there can be no good reason given why it should not in the second, and in fact in all cases of a disregard of instructions and thus overturn the whole land system. *Yet I apprehend that the legal character of these corners and boundaries is not dependent on their conformity with the prior instructions of the Surveyor-General*, *but solely upon his subsequent approval and return of them in conformity with the requirements of the act of February 11, 1805*, and still less will the mere intent with which the U. S. deputy may have run a line, fix its legal status, without those requirements of the law.

And then the statement "that the surveyor ran the line between sections 2 and 3, and set his corner post to define that line," is not a full and correct statement of the facts in the case, for he actually set the post to establish the corner, as his quoted notes show: "North between *sections 2 and 3*, 82.02 intersected N. boundary, (post removed.) Set post at intersection, *corner to 2 and 3*." This corner so established, when returned by the Surveyor-General, became the proper corner; and the corner thus established defined the line as the proper boundary line.

And as regards the further point made, "that no lines were ever run from the intersection corners that were intended for township boundaries," this may be answered in the same manner as before; that whether run or not for that purpose, the intention of the deputy is not a material fact; but his acts, and the *intention* of the Surveyor-General in the adoption or approval of those acts as evidenced by his returns, is what gives the legal character to the corners and boundaries under the act of 1805. And further, that the lines from these intersection corners to the nearest section corners on the exterior surveys, were actually compassed and chained as per instructions, is shown in most every instance by the returned plats and notes of intersectional fallings; and all other lines from these intersection corners not actually run and marked, would, by virtue of the concluding part of the 2d clause of the 2d section, be legally established.

With regard to the authorities quoted to sustain the exterior line, the extract from the instructions of the Commissioner of the General Land Office of 1881, that "new corners on township boundaries must be established by survey of such lines, and in no case will such corners be established from data acquired in running lines clos-

ing on such boundaries." These words follow after, and I understand have exclusive reference to, the cases there stated, viz: "Where subdivisional lines have been closed upon a township boundary *in advance* of the preliminary survey of the same, its *allignment will not be changed.*" "If it is found necessary to establish new corners on such boundary, they will receive only the marks referring to the sections in the township being subdivided, and the marks on the old corners on such boundary, which refer to such sections, will be obliterated," or in other words random or temporary subdivision corners made before any township line is run, are not to control the running of the township line, but are to be corrected to conform to that line when run; just as all other random corners are corrected into line and distance, and any other interpretation of the instruction would conflict with what, immediately preceding it, is laid down as the rule to govern the surveys; as also what is contained in the instructions of March 13th, 1883. For instance, the instructions of 1881 contain the following: "The original corners, when they can be found, must stand as the true corners they were intended to represent, even though not exactly where strict professional care might have placed them in the first instance." "Again, as has been observed, no existing original corner can be disturbed." Also, "If, in subdividing a township, it is found that the exterior boundaries have been improperly run, measured or marked, or the corners established thereon have been obliterated, the deputy will re-survey so much of said exterior boundaries as may be necessary, and establish new corners upon the same whenever necessary. Where *no subdivisions have been made on either side of a township boundary*, it will be corrected if necessary in point of allignment as well as measurement, by establishing the section corners at lawful distances from the south or east boundaries of the township (as the case may be), and upon a right line extending between the township corners; and in such case, the old corners on said township boundaries will be destroyed." Now when is the allignment to be corrected? Only where *no subdivisions have been made on either side of the township line.* And why? Obviously for the reasons before given, that "the existing original corners can not be disturbed even though not where they should have been placed."

And then the instructions of March 13th, 1883, uses the following language: "That the original township, section and quarter section corners established by the government surveyors must stand as the true corners which they were intended to represent, whether the corners be in place or not." And again, where double corners were originally established, one of which is standing, to re-establish the other: "Having determined to which township the existing corner belongs, the missing corner may be re-established in line north or south of the existing corner, as the case may be, at the distance stated in the field notes of the original survey, and tested by measurement to the opposite corresponding corner of the section to which the missing section corner belongs."

Here a corner that was made in running the exterior boundary line, and which is lost or destroyed, is authorized to be re-established from the subdivisional sectional corner; that is, *from data of lines closing on such township boundary.* Now, as a matter of fact, not one in a hundred of these subdivisional corners will allign with the surveyed corners of the exterior boundary, and if for that reason they are not to be considered as the proper corners of the sections, then there is a manifest inconsistency, if not positive error, in ruling that such a corner has the power to fix a boundary and re-establish a lost corner in that line. For myself, believing that under the act of February 11th, 1805, all these subdivisional corners are the proper corners of the sections which they were intended to designate, I, of course, regard the instruction as strictly correct, and the proper thing that should be done to restore the lost exterior corner; and such must have been the construction given to the act of 1805, by the Land Department, as to the character of these subdivisional intersection corners, or else the instruction would not have been given.

And now, with regard to the extract from the opinion of the Commissioner of the General Land Office cited, in which that official is quoted as saying that "the township line is also the boundary line for sections just south of that line, and the fact that certain closing corners were established somewhat beyond that line does not change that line, which must be the true line between the sections north and south of it." This, while in direct conflict with the previous rulings and regulations of the department, as just shown by the quotations from the instructions of 1881 and 1883, yet is in no sense an authoritative determination of the question, for while the opinions of the Commissioner, as to the proper construction to be given to the rules and regulations of the department, are almost conclusive, yet when the question is as to the proper interpretation to be given to an act of congress, his opinion, while entitled to respect, is of no higher authority than that of any other equally competent lawyer. And I have the opinion of a number of lawyers, in every respect his peers, who coincide with the views I have expressed; and further, I am informed by Gov. Palmer that in his own practice he knows of the question being judicially determined in the same way, in the circuit court in this state, in a case wherein he took my position as to the law.

Then for the reasons, that the act of 1805 has made no distinction between the boundaries of sections, whether they form parts of the exterior boundaries of townships or of interior sections, but treats them all as equals; that its provisions are mandatory, and declare that these boundaries shall be ascertained by certain principles, and consequently no other principles can be applied; that these principles which are to ascertain the boundaries are the corners and lines marked in the surveys returned by the Surveyor-General; that these corners and lines marked in the surveys are the corners and lines indicated or shown on or by the plats and notes, and the surveys re-

turned are these plats and notes prepared by the Surveyor-General, by which the lands were to be sold, and that were sent by him to the district land offices and the copies of the same sent to Washington; that these plats were not skeleton township plats, but full and complete subdivided or sectionized township plats; that being returned as entireties or units, the act took effect and force upon all the corners and lines at the same moment of time, and established each as the proper corner or line which it was intended to designate; and as the returns by the Surveyor-General are what establishes the legal status of the corners and lines, that consequently there can be no question as to prior or subsequent survey, or the intention for which corners and lines were made by the U. S. deputy surveyors, non-conformity with instructions, etc.; that in the application of these two principles of corners and lines to the question of boundary, it should be remembered that there is no conflict between the corners of the two surveys (for the intersectional corners and lines are rejected by the advocates of the exterior survey line not because they conflict with the corners of the exterior survey, but for the reason that they conflict with that line, while those claiming the modified township line accept all the corners of both surveys as the proper corners, and only change the exterior survey line so far as may be necessary to make that line conform with the intersectional survey corners); that being limited in the decision of this question to the two principles of returned corners and lines, the issue then is a returned line against a returned corner and line—that is, a principal of a lower grade vs. a principle of the same grade and also a principle of a higher grade; that the courts would in this case regard the corners as the higher and controlling principle is evident from the well settled construction they have given such calls in grants and deeds; that such a construction would be in accord with the spirit and obvious intent of the regulations and instructions relating to the surveys, as the same have been interpreted by the land department from the beginning (with this one exception of Commissioner Sparks's opinion); that to enforce the construction given by Commissioner Sparks would blot out and destroy twenty intersectional corners in every township, for no such accident could hardly happen as that one of them should be in exact line; and that, though not in any published reports, it has nevertheless been judicially determined that the modified line is the true township line; and for other reasons which might be presented if the length of this article would permit, I can not doubt for a moment that the modified town line is the correct line.

ROCKFORD, ILLINOIS.*

By D. W. MEAD, of Rockford.

Rockford, the county seat of Winnebago county, is situated in latitude 42° 14′ north, and longitude 89° 5′ west. The altitude of the lowest point in the city above sea-level is about 696 feet. The town was first settled in 1834, was organized in 1849 and received a special charter in 1854.

The city is divided by the Rock River, which flows from the northeast to the southwest, and is here from 400 to 600 feet in width. The west side is further divided by Kent's creek and its two branches, while the east side is similarly divided into drainage valleys by Keith's creek and a dry run. The city is situated in the hilly district of northern Illinois and has a more uneven topography than most cities of the state, having an extreme difference in elevation of about one hundred and twenty feet.

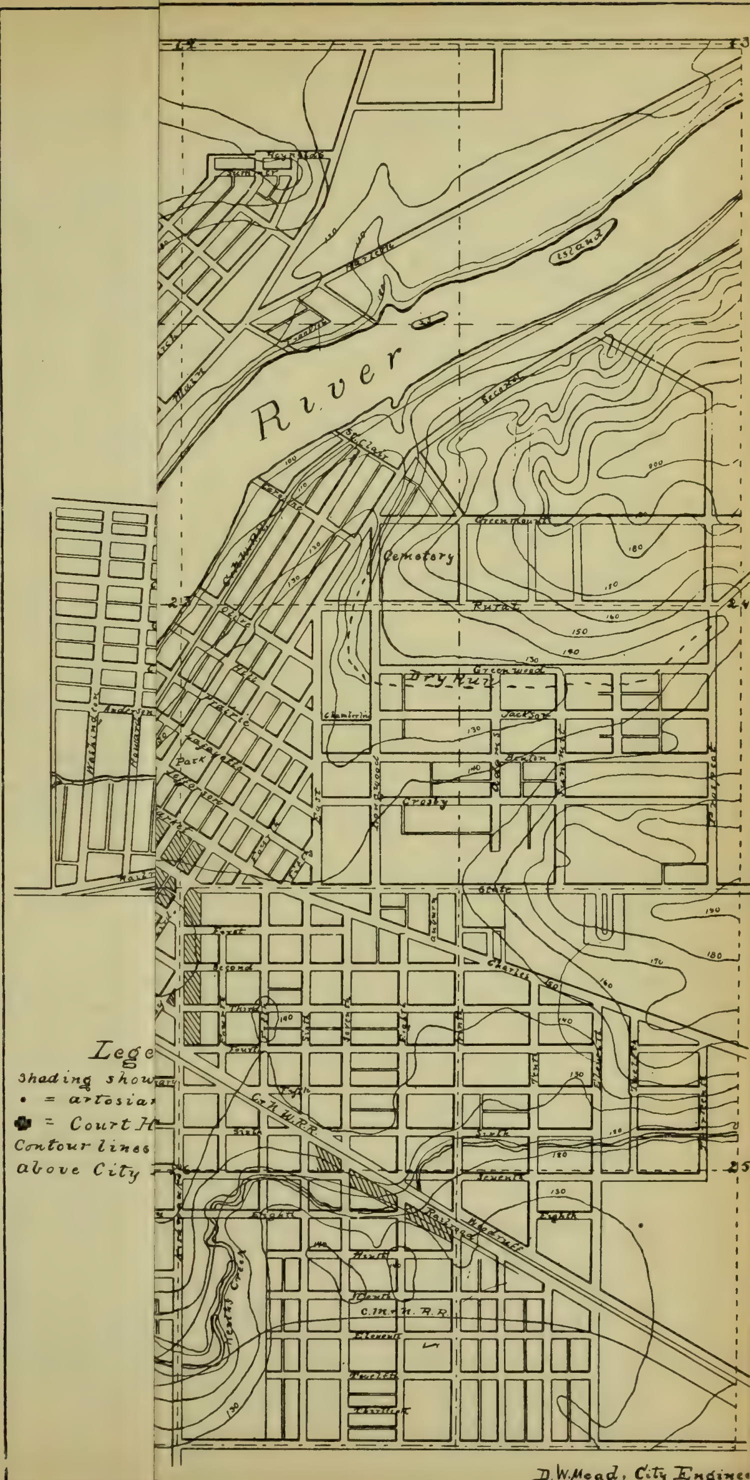
The area of Rockford is about 4300 acres. Most of the land, except some immediately adjoining the creeks, is available for building purposes without filling. A dam built across the river not far from the center of the city furnishes excellent water power.

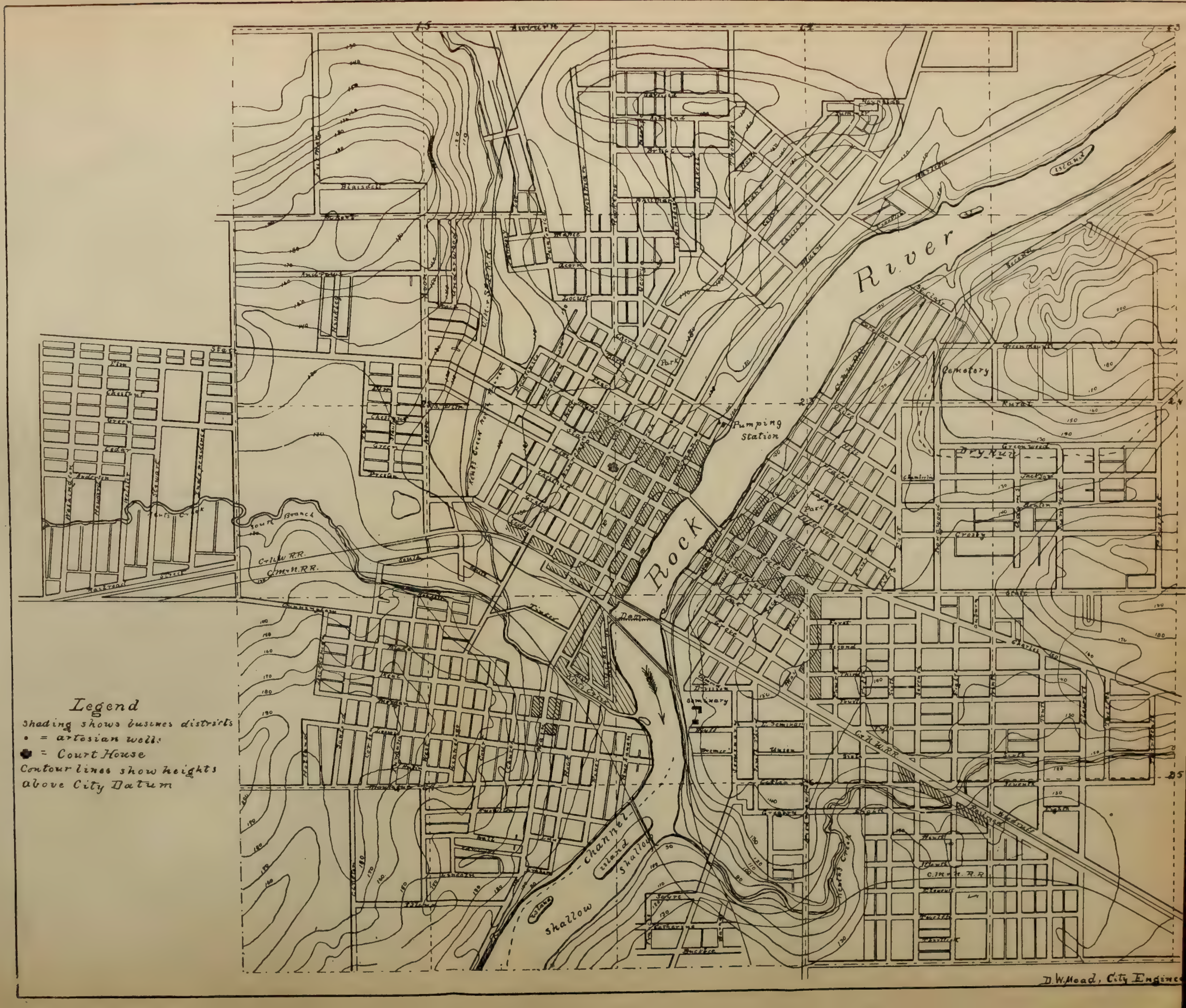
Geology.—The Galena limestone has natural outcrops at many points in the vicinity. The best quarry yet developed is in the northern part of the city, where excellent building stone is obtained. This stone is of a light buff color. It is rather coarse in texture and can not be very smoothly finished on this account. The best of the stone hardens on exposure and is believed to be quite durable. It has been used for arch bridges and bridge abutments, besides for ordinary building purposes, and has given very fair service.

Climate.—The temperature at this point ranges from a maximum summer temperature of about 90° F. to a minimum winter temperature of about —25° F., although both colder and warmer weather are occasionally known.

The precipitation may be seen from the following table as ascertained by Mr. T. D. Robertson, local volunteer observer United States signal service:

*Given as an appendix to the report of the committee on Municipal Engineering.


River
Island
Main
St. Clair
Cemetery
Greenmount
Rural
Dry Run
Greenwood
Jackson
Crosby
Longwood
East
Park
Lafayette
Jefferson
Prairie
Washington
Howard
State
Charles
Forest
Second
Third
Fourth
Fifth
Sixth
Seventh
Eighth
Ninth
Tenth
Eleventh
Twelfth
Thirteenth
C. & N. W. R.R.
Railroad
Woodruff
Kents Creek
130
140
150
160
170
180
190
200
Lege
shading show
• = artosia
= Court H
Contour lines
above City
D.W. Mead, City Enginee


Legend
shading shows busines districts
• = artesian wells
= Court House
Contour lines show heights above City Datum
Rock
River
Pumping Station
Cemetery
Seminary
Dam
channel
island
shallow
Shallow
Park
State
Auburn
Blaisdell
Rural
Greenwood
Jackson
Crosby
C.&N.W.R.R.
C.M.&St.P.R.R.
C.B.&Q.R.R.
Kent's Creek
Keith Creek
D.W. Mead, City Engineer

YEARS.	Sep.	Oct.	Nov	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Annual.
1872–73.....			1.10	1.17	2 89	0.24	2.50	1.66	5.06	3.96	2.32	2.82	(10 mos. 23 72
1873–74.....	1.68	1.72	1.63	2.36	4.87	0.83	1.01	1.23	1.09	3.39	0.90	1.19	21.90
1874–75.....	5.97	1.00	3.34	0.89	0.75	1.56	0.59	3 06	2.25	6.21	5 96	2.15	33.73
1875–76.....	3.56	2.34	0.50	0.65	3.76	2.91	2.84	3.83	6.06	4.25	5 80	2.42	38.92
1876–77.....	4.71	1.50	4.37	0.41	3.06	0.03	5.53	3.99	2.20	4.32	1.96	4.04	36.12
1877–78.....	0.61	6.15	3.90	2.00	0.65	0.52	3.63	3.44	4.20	3 48	5.75	1.99	36.32
1878–79.....	0.85	6.03	0.78	1.48	0.71	1.32	0.91	2.76	2.19	3.63	6.98	3.06	30.70
1879–80.....	0.40	1.93	5.35	1.18	3.19	1.92	2.70	4.53	4.11	5.88	1.74	2.98	35.91
1880–81.....	3.51	1.20	1.94	0.60	1.71	6.50	3.49	1.38	2.39	6.44	7.72	0.33	37.21
1881–82.....	3.72	5.37	2.17	2.99	1.19	2.01	3.54	5.15	3.42	5.69	2.96	3.82	42.03
1882–83.....	0 93	3.32	2.24	2.49	1.98	3.76	0.57	1.96	6 39	4.21	3.96	1.50	33.31
1883–84.....	0.92	6.66	3.87	1.58	1.42	1.91	2.88	3.45	3.43	6.16	6.13	3.68	42 09
1884–85.....	3.85	6.24	1.99	6.51	2.39	2.50	0.26	4.33	2.39	5.47	4.50	9.18	49.61
1885–86.....	4.64	3.95	1.96	3.57	5.87	3 40	4.55	4.36	4.93	2.74	0.35	8.42	48.74
Means	2.72	3.65	2 51	1.99	2 46	2.10	2.50	3.22	3.58	4.63	4.07	3.40	37.43

Business and Population.—The water power at Rockford has been extensively utilized by various manufacturers. Agricultural implements and furniture are the chief productions, although watches, watch cases, plated ware, cutlery, machinery, woolen goods, stockings, etc., form an important part. The character of the business enterprises is cautious and conservative. There is very little investment in doubtful schemes but solid business finds ample support. The same spirit pervades the municipal works; improvements come slowly and only when plainly necessary.

The increase in the population will be seen from the following table:

1850,	2,093	1880,	13,129
1860,	6,979	1884,	19,533
1870,	11,049	1887,	22,217
1877,	12,738		

The present population is quite largely composed of foreigners, among which Swedes predominate.

Finance.—The municipal year begins on the first day of May. The fiscal year formerly began on the same date, but has been changed to January 1st, a much better arrangement, as it allows the year's work to begin early in the spring. By this change the old board of aldermen, who are familiar with the necessities of the city, make the appropriations for the next year. The annual appropriation bill must, according to the state law, be passed during the first quarter of the fiscal year, and no other moneys can be appropriated except in case of emergencies. The state law limits the annual appropriation as follows:

"The aggregate amount of tax levied for any one year, exclusive of the amount levied for the payment of bonded indebtedness or the interest thereon, shall not exceed the rate of two per centum upon the aggregate valuation of all property within such city or village."

The indebtedness of the city is also limited by the following general law:

"No * * * * municipal corporation shall be allowed to become indebted in any manner or for any purpose to an amount, including existing indebtedness, in the aggregate to exceeding five per centum on the value of the taxable property therein."

The valuation of property in the city for the year 1887 was as follows:

Land	$ 420,139 00
Lots	2,498,999 00
Personal	1,618,444 00
Corporations	14,302 00
Telegraph and Telephones	3,070 00
Railroads	117,294 00
Total	$4,672,248 00

—making the limit of indebtedness $233,612.40, and the available tax levy $93,444.96, exclusive of the amount which may be raised to pay the interest on the bonded indebtedness. The bonded debt of the city is now $208,200.00, leaving the city $25,412.40 from the limit.

The appropriations for the coming year 1888 are made up as follows:

Surplus from appropriation of 1887	$ 36,413 51
Estimated income from license	48,100 00
Bonds (to be issued)	10.000 00
Tax levy (for interest on bonds)	8,021 00
Tax levy (for expense)	93,207 86
Total appropriation	$ 195,741 37

The valuation of property for 1886 was about $80,000 more than for 1887, and the total appropriations for 1887 were $216,687.12, divided as follows:

Sinking fund	$15,500 00
Interest fund	14,464 22
General fund (salaries of elective officers)	4,250 00
Special loan warrants	1,673 19
Miscellaneous	2,341 00
Police	11,437 00
Fire Department	16,596 12
Health Department	1,515 00
City Lights	13,400 00
Public Parks	500 00
Legal Expenses	625 00
Water-works fund	36,338 96
Street funds	22,719 58
Sewer fund	4,556 82
School fund	53,476 00
Library fund	4,500 00
School building fund	12,794 23
Total appropriation	$216,687 12

While the general expenditures are provided for by the annual city tax, local improvements, as street improvements, paving, macadamizing, sewers, sidewalks, &c., are provided for by special taxation on the frontage, or by special assessment on property benefited, the public paying its share of benefits derived. The last method has caused considerable dissatisfaction whenever used, as it is often hard to decide justly and equitably the amount of benefit which property will derive from any improvement.

Management of Public Works.—All public works of the city are under control of the city council and are directly managed by committees of the council and by the executive officer in charge of the work.

The following shows the number and duties of the city officers connected with the public works:

Name of Officer.	*Yearly Salary.*	*Duties.*
Mayor	$ 600	Presiding officer of council; chief executive.
Aldermen (14)	100	Legislative; act here as executive also.
Street Commissioners (2)	900	In charge of streets under street committee. Appointed by mayor.
Supt. of Water-Works	1200	In charge of water-works, extension and maintenance. Appointed by mayor.
Supt. of Sewers	——	In charge of maintenance of sewers. Supt. of water now acts as this officer. Appointed by mayor.
Health Officer	450	Executive officer of the boord of health. Appointed by mayor.
City Engineer	$5 per day when employed	Designing sewers, bridges, and street improvements. Gives grades and makes surveys and plans for any public works when called upon by committees. Appointed by mayor.

Streets and Alleys.—There are about one hundred miles of streets in the city. Their usual width is 66 feet; commonly 10 feet on each side is given to sidewalks, trees and curb. In several streets, however, the experiment has been tried of narrowing up the roadway to from 30 to 36 feet and of allowing the property owners to curb in the remainder and seed it to grass.

About four miles of street has been improved by macadamizing with local stone. This has not been very successful, as the stone soon powders under the combined action of traffic and frost. About five miles of gravel roadway has been made and gives much better satisfaction than that of macadam. About one-half mile was improved in 1886 under the following specifications and has given good satisfaction.

Extracts from specifications: "The streets shall be excavated or filled by the city to the grade given by the city engineer, and the surface prepared by said city for receiving the rubble.

"On the surface so prepared a layer of large-sized rubble shall be thrown. This course shall be arranged in a close and compact form, and the interstices of the larger stones shall be filled in with

sound stone chippings, all to the satisfaction of the commissioner of streets. The stones for the foundation course shall be generally not less than five inches in any dimension.

"Over the foundation course a layer of rubble broken as nearly as possible to a cubical form, not less than one and one-fourth inches, nor more than two and one-half inches in any dimension shall be placed. The rubble shall * * * * be well compacted and rolled with the city roller, to the satisfaction of said commissioner of streets.

"Over the rubble a layer of screened gravel mixed with clay shall be placed. The layer shall be when finished at least two inches in thickness at the center and one inch in thickness at the side. This layer shall be well rolled and compacted with the street roller to the satisfaction of said commissioners.

Both before and while rolling the rubble and gravel layers said layers shall be flooded or sprinkled. * * * *"

The city has a horse road roller weighing about three thousand pounds, which is much too light to be of value.

Considerable trouble is occasioned, and considerable expense caused the city, by the miscellaneous way in which improved streets are dug up for gas, water, sewers, &c., and the lack of care in replacing the same. In the report of the committee on streets and alleys for 1887 the annual expense from this cause is estimated at from $1,500 to $2,000. The following extract from the report of the city engineer for 1887 bears on this subject: " * * * No street, no matter how well laid or how excellent the material, can be properly maintained if it is constantly disturbed for repairing or laying underground pipes and conduits. All such pipes or conduits should be laid or thoroughly repaired before any improvement is undertaken, and if at any later time it becomes necessary, as it certainly will, to make openings in the streets they should be made only by permission of the city officers having charge of streets and under their immediate supervision, and such permits should be granted only on the payment of the estimated necessary expense of properly replacing the same."

The city datum plane is assumed at 100 feet below high-water mark at the city bridge and is fixed by bench marks on various public buildings throughout the city. Grades for street centers have been established on about fifteen miles of streets and the intention is to establish the remainder in the immediate future. Generally the intersection of streets between curbing is made level. The maximum gradient established is 1 in 18, although it is intended to keep below 1 in 25 when possible.

The gutters are carried under the intersecting streets either by wooden or pipe culverts. The latter have not been very successful, as they are apt to freeze up; and even the wooden culverts are opened and cleaned occasionally when freezing and thawing succeeds each other for some time. The principal streets are cleaned when con-

sidered necessary, but only after heavy rains, when the mud is hoed up and carted away.

Shade trees are planted along most of the residence streets and are cared for by property owners. They are mostly oak, maple, elm, walnut, and some other varieties.

There is no system of garbage removal established, although there is some talk in that direction. Ashes, &c., are carted off at individual expense and dumped in any convenient out-of-the-way place. Cesspools and vaults are cleaned by licensed night scavengers.

There are five small parks, one 265 feet by 330 feet, one 330 feet square, and three small triangular ones.

The streets of the city are lighted by gas, posts being placed on diagonal corners of each intersection and at the centres of the blocks in the business portion of the city, and at each intersection, alternating on the two sides of the street, through the residence portion. There are 456 lamps in the city, and they are lighted at an expense of $24 per lamp per annum.

The houses are numbered north and south from State street and east and west from the river, each block having 100 numbers.

Monuments.—The monuments used for marking the center lines and angles of streets are of several varieties. Limestones cut about four inches square on top and about two and one-half feet in length are used in places. Granite boulders from the glacial drift, when they can be found of proper size, are used, a hole being drilled in the top for a center, The most of the monuments at present, however, are $\frac{3}{4}$-inch round iron rods about two and one-half feet in length. These are commonly surrounded by a cast iron cap having a movable top. The cap being placed flush with the surface of the road makes the monument readily accessible.

Considerable trouble has been occasioned in the past on account of the absence of proper monuments to mark the locations of streets. At the beginning of the year 1886, the council ordered work begun for establishing as nearly as might be the center lines of streets and marking the same in some prominent manner.

The work in the older part of the city where all original marks were lost was carried on as follows: A section of street shown on the plats as straight was taken as far as it continued in one subdivision. Along this street at many places measurements were made between fences on the opposite sides of the street and surveyor's pins stuck up in the centre as found. A transit was then set up as near the centre of the street as possible and moved one way or the other as the average line through the row of pins would indicate. When the line was found that would average up the pins in the best manner, iron pins were driven to mark its position. When the cross streets were run, iron pins were driven at the intersection of the two lines. These were called preliminary monuments. Between these preliminary monuments measurements were made and checked. Measurements were also made to various lines supposed to be correct.

From the plats and from all other sources possible, information was gathered and the preliminary monuments were finally located as the evidence seemed to determine.

Although it is probable that the original lines were not always exactly found, it is believed that the lines as fixed will become the permanent lines, for the following reason: There are no surveyors in the city who had to do with the original survey of the city, and as new men coming into the place will have nothing better to work from, the lines will become fixed by common acceptance and by limitation.

Bridges.—For bridge work general specifications or instructions to bidders similar to the following are used:

General specifications for superstructure for an iron bridge over Kent's creek on School street, Rockford, Illinois:

1. The superstructure shall be seventy (70) feet in length, over all, with a sixteen (16) foot road way.
2. The centre line of the bridge will make an angle of seventy-three (73) degrees to the right with the face of the abutments.
3. The floor will be about fifteen (15) feet above the bed of the stream.
4. The structure shall be proportioned to carry the following loads, in addition to the weight of the structure itself, with a factor of safety of four (4):
   (*a*) For trusses, ninety (90) pounds per square foot of road surface.
   (*b*) For floor beams, beam hangers and hip verticals, one hundred (100) pounds per square foot of road surface.
   (*c*) For wind pressure, three hundred (300) pounds per lineal foot of span.
5. All parts of the structure shall be wrought iron, except the flooring, floor joist and wheel guards.
6. The floor plank shall be pine plank, three (3) inches thick, laid with one-quarter ($\frac{1}{4}$) inch openings and spiked to each supporting joist.
7. The floor joists shall rest on the iron floor beams, and shall be spaced not over two (2) feet centers, lapping each other to give full bearing. Their dimensions shall be taken from the following table:

For	10	foot panel	length	3	inch	× 12	inch joist.
"	12	"	"	$3\frac{1}{2}$	"	× 12	"
"	14	"	"	4	"	× 12	"
"	16	"	"	4	"	× 13	"

8. All parts of the structure shall be so designed that the strain coming upon them can be accurately calculated.
9. Bidders, in submitting proposals, must furnish complete strain sheets, general plan of proposed structure, and such detail drawings as shall clearly show the dimensions of all the parts, mode

of construction and section area of members. The data on which computations were made must be also given.

10. All workmanship and material must be first-class in every respect, and must be satisfactory to the Street Committee and the City Engineer.

11. Bids must be made for the superstructure complete and ready for use.

The specifications used for masonry substructures are usually about as follows: Masonry shall be of good quality of rock-face range work; stones to be squared, bedded and laid in courses not less than twelve inches or more than twenty-four inches in thickness. The beds of stretchers shall be not less than fourteen inches in depth for twelve-inch courses, and for courses over fourteen inches in width the depth of bed must equal the width of face. They shall be not less than two feet in length. The headers shall have not less than twelve inches width of face. The interior and back of the masonry shall be constructed of similar like-sized stones, and in such manner as to be well bonded together. All stones shall be laid on their natural bed. The interstices shall be filled with sound stone chippings and grouted full.

* * * * * * * *

"All materials used and all work done must be satisfactory to the City Engineer, and any work done or material used not satisfactory to said engineer shall be immediately removed and work and material of required quality substituted."

Water Supply.—The following items from the reports of the committee on fire and water and the superintendent of water-works, for the year 1886-87, will give a general idea of the water supply of the city:

Owned by City of Rockford.
Date of construction, 1875–6.
Source of supply, artesian wells.
Mode of supply, direct pumping.
Builders of machinery, Holly Manufacturing Company.
Total cost of works to date, $342,509.
Coal used, bituminous, average cost $2.18.
Coal consumed, in pounds, 1,610,832.
Total pumpage, in gallons, 529,982,759.
(a) Average dynamic head in feet, 131.
Gallons pumped per pound of coal, 329.
Boilers evaporate, by measurement, 4½ to 1.
Cost of pumping, on pumping-station expenses, $5,525.98.
  Per million gallons against head (a), $10.43.
  Per million gallons one foot high, $0.08.
Cost of pumping, on total maintenance, $9,192.77.
  Per million gallons against head (a), $17,34.
  Per million gallons raised 1 foot high, $0.13.
Gross revenue per million gallons, $30.00.
Net revenue per million gallons, $12.66.

Statement showing total mains and size, hydrants and valves:

Sizes of pipe.	*Per cent. of total mains.*	*Feet of main.*	*Mains to Hydrants.*	*Conduits and Suction.*	*Valves.*
Under 2-inch	0.2	3,335			3
2-inch	19.3	30,587			30
4-inch	31.7	49,187	6,145		69
6-inch	23.0	35,680	200		40
8-inch	15.2	23,638			23
10-inch	5.2	8,070			4
12-inch	3.3	5,135		563	5
16-inch	0.3	545		480	3
20-inch				24	1
24-inch				112	
Totals	100.0	156,160	6,345	1,179	178

Total miles main, 29.57. Total miles, 31.

The supply was formerly drawn from the Rock River and was quite impure. In 1885 an experimental well was sunk near the water-works buildings. A fine flow of water was struck. Since this, three other wells have been sunk and a fifth is proposed for the coming year. The depth and cost of these wells may be gathered from the following:

Total investment in wells, $18,238.54

Well No. 1, 1,530 feet deep, cost $3.53 per foot.

Well No. 2, 1,320 feet deep, cost $1.87 per foot.

Well No. 3, 2,000 feet deep, cost $2.13 per foot.

Well No. 4, 1,300 feet deep, cost $1.66 per foot.

These wells derive their supply from the Potsdam sandstone, which outcrops through central and northern Wisconsin. The water is of an excellent quality.

The following are some of the annual water rates as fixed by ordinance:

Bakeries	$8.00 to $10 00
Bath tubs, private	3 00
" " each addit'al tub	2 00
" public, each tub	5 00
Boarding houses, per room	1 00
Barber shops, one chair	3 00
" " each addit'al chair	2 00
Breweries, special or meter rates.	
Building purposes, per 1000 brick	10
" " plastering, per hundred yards	20
Building purposes, stone per cord	10
Banks	6 00
Cisterns filled	$2 00 to 5 00
Churches	5 00
Churches, for baptistry	10 00
Drug stores	$10 00 to 15 00
Eating houses (or meter rates).	$10 00 to 20 00
Fountains, one-eighth-inch jet, 10 hours a day, for the season.	15 00
Fountains, each additional one-eighth-inch jet	$ 2 00
Fountains, one-sixteenth-inch jet for the season	8 00
Fountains, each additional one-sixteenth jet	2 00
Houses, six rooms or less	5 00
Houses, each additional room	50
Houses, six rooms or less, with sprinkling 66 feet front or less combined from yard hydrant, per annum	7 00
Hotels, per room	1 00
Manufacturing establishments: special or meter rates.	
Offices occupied by not more than two persons	3 00
Offices: each additional person	1 00
Printing offices, boilers extra	$10 00 to 25 00
Public halls	10 00

Stores, twenty feet front or less..	5 00
Stores, for each additional foot of frontage........................	10
Saloons, exclusively for bar-room and scrubbing purposes.........	15 00
Stables, livery, sale and feed, per single stall, including washing carriages	1 25
Stables, private, one horse and cow, or two horses, and washing carriage........................	3 00
Stables, private, each additional horse...................................	1 00
Steam boilers, per horse power, for each twelve hours............	2 00
Steam boilers, per horse power, for each twenty-four hours.....	3 50
Urinals, self-closing.................	3 00
Urinals for hotels, boarding houses and saloons, and using one-eighth-inch jet................	5 00
Water carts, per hundred gallons	05
Water closets, private................	2 50
Water closets, public, each bowl..	5 00
Yard sprinkling, 66 feet front or less, 166 feet deep or less, with a nozzle not over one-fourth of an inch in diameter, for season from April 1st to Nov. 1st.......	4 00
Yard sprinkling, each additional foot front over 66 feet..........	06
Sprinkling carts, per wagon per month.................................	8 00

METER RATES.

Three hundred to four hundred gallons per day, per hundred gallons	04
Four hundred to one thousand gallons per day, per hundred gallons................................	3½
One thousand to five thousand gallons per day, per one hundred gallons..........................	2½
Five thousand gallons and upwards per day, per one hundred gallons..........................	02

All manufacturing and other establishments requiring a large supply of water may be required to use a meter furnished by the City of Rockford at the expense of the consumer.

Sewers.—The city has good natural drainage and consequently the demand for sewers has not been imperative. The city has spent about $25,000 in sewers, but most of the work has been done with regard for only local needs and immediate demands. A sewer system is now under consideration and a plan will probably be adopted before spring.

Already one district sub-system has been constructed which is intended to work into the proposed general system. This district is drained by a 12-inch sub-main and 8-inch laterals. At each point of junction of the lateral with the sub-mains, manholes with ventilating caps are built. Half way between the manholes, at the ends of laterals, and half way between manholes and end of laterals, lampholes with ventilating caps are placed. A new style of catch-basin is used on this line in order to provide sufficient flushing. At deep cuts equalizers are provided to allow of house connection without too deep digging. The position of all Y connections was recorded and was also marked by a 2x2-inch pole.

The following specifications were prepared with considerable care for this district, and were found to work admirably:

Specifications.—The entire work is to be done under and in accordance with the directions of the City Engineer or his authorized agents, subject to the approval of the council committee on sewers. Should there be any doubt as to the meaning of these specifications,

or any obscurity in the wording of them, or should there appear any discrepancy between them and the plans, the engineer shall explain them, and such explanation shall be final and binding upon the contractor, who shall not make any charge or claim for extra work or damage in consequence of such explanation, but will execute the work in accordance therewith.

Plans.—The sewers are to be built of the material, size and dimension, with the connections and manholes on the line and grade, and in the manner shown on the plans filed at the City Engineer's office. All dimensions, materials, lines and grades must be in accordance with the plans unless otherwise ordered in writing by the engineer. The contractor will be furnished with a complete set of drawings or tracings, showing all the details and dimensions necessary to carry out the work. Dimensions given thereon in figures are to have preference over the scale.

The plans and a copy of these specifications are to be kept constantly at the work by the contractor.

The plans and specifications are intended to include whatever may be requisite to render the work complete, but should anything be accidentally omitted, the same shall be executed by the contractor without extra cost to the city of Rockford.

Excavating.—The ground shall be excavated in open trenches to the necessary width and depth, and in such directions as the engineer shall direct.

The material shall be deposited on the sides of the trenches, beyond the reach of slides.

The banks shall be kept trimmed up, so as to be of as little inconvenience to the public travel as possible, or to the tenants occupying adjoining property.

The trenches shall be one foot wider on each side than the greatest external horizontal width of the sewer intended to be laid in them, unless the nature of the ground necessitates a greater width, which shall be determined by the engineer.

If running sand, quicksand, or other bad and treacherous ground be encountered, the work shall be carried on with the utmost vigor, and shall be proceeded with day and night should the engineer so direct.

Should any bed rock be met with, the contractor shall be paid the price of three and 75-100 dollars per cubic yard for excavating the same, in excess of the contract price for said sewer work. The rock shall be taken out to the depth, width and in the manner directed by the engineer. No disintegrated or loose rock shall be embraced in the above; and the amount to be paid the said contractor shall be based wholly on the engineer's returns for the amount of rock excavated.

Whenever it may be necessary to cross or interfere with existing culverts, drains, sewers, water-pipes or fixtures, gas-pipe or fixtures or other structures needing special care, notice shall be given to the en-

gineer, and the work shall be done according to his directions. All objects needing it shall be sustained securely in place until the work is completed. Any damage caused shall be thoroughly repaired; and all work requiring it shall be strengthened to meet any additional strain, that the work herein specified may impose upon it.

All paving, graveling, macadamizing, planking, sidewalks, culverts, and cross-walks, or any street paving or walk whatever on the line of the excavation, are to be carefully removed before the excavation is made, and to be kept apart from other excavated material. If so required, the excavation shall not advance more than one hundred (100) feet ahead of the completed masonry or pipe-work; but the excavation shall be completed at least twenty (20) feet ahead of pipe-laying, unless otherwise ordered by the engineer. No tunneling will be allowed except by written consent of the engineer. All irregularities in the bottom of the trenches shall be filled up to the required level with gravel or clean sand, firmly rammed in; and where the ground does not furnish a sufficiently sound foundation, the contractor shall excavate the trench to such increased depth as the engineer may decide to be necessary, and shall then bring it up to the required level and form, with such material and in such manner as the engineer shall direct.

SHORING.—The sides of the excavation shall be supported by suitable planking and shoring whenever necessary in the opinion of the engineer; and in all cases the same is to be withdrawn as the work progresses, unless otherwise ordered by the engineer.

Whenever it is thought necessary by the engineer, the timber shall remain in the trench after the completion of the work, and the contractor shall be paid therefor by board measure, at current rates.

The contractor shall, at his own expense, pump out, or otherwise remove, any water which may be found or shall accumulate in the trench, and shall also construct all dams or other works necessary for keeping the excavation clear from water during the progress of the work.

The contractor shall keep streets and highways, in which he may be at work, open for carriages to pass, so far as may be practicable, and shall bridge the trench at all street crossings, roads or private ways, and shall conduct his work for this object in such a manner as the engineer may from time to time direct. No sidewalk shall be obstructed when it is possible to avoid it. * * * *

FILLING.—After the sewer is built the trench shall be filled back and carefully packed and rammed with proper material and with proper tools, or otherwise compacted, to the approval of the engineer. The trench shall be filled with good sharp sand or loam to nine (9) inches above the crown of the sewers, and then with a layer of nine (9) inches of earth, free from stones or brickbats, and well and carefully pounded all over with a suitable rammer, before any other material is filled over it. Every successive layer of earth one (1)

foot high, or as directed by the engineer, shall be pounded in the above described manner. Any part or parts of the filling shall be flooded or puddled if so directed by the engineer. The engineer shall decide whether the material is suitable to fill back over the sewer, and in case the excavation does not furnish a sufficient quantity that is suitable, the contractor must provide such as will be. As the trenches are filled, the contractor shall replace all material to the satisfaction of the engineer, and shall remove all superfluous material, leaving the streets free and clear and in good order.

The pavement shall be made as good as possible consistently with the performance of the work. The back filling and removing of material shall follow closely upon the pipe-laying or brick work. And in case of delay or neglect in this work, or in the paving, the engineer may, after one day's notice, do the work, and the cost shall be deducted from any payment due the contractor.

Material.—All bricks, pipe connections, cement, iron work and stone, and all other materials of whatever nature, whether needed permanently or temporarily, and all labor necessary to the full completion of the work ready for operation, unless otherwise specified, are to be furnished by the contractor and included in the prices bid.

All necessary fencing, lighting, watching, providing necessary passage for travel, clearing away surplus material, and restoring the street to good condition for travel, are to be included under the above head.

The City of Rockford reserves the right to increase or diminish the gross length of the sewer, amount of masonry and material with corresponding excavations which are contained within the limits of the plans, to the extent found necessary by the engineer. No allowlowance will be made in any case of increase for any sum above the prices bid, nor in case of decrease for any real or supposed damages, or loss of profit occasioned by such diminution, but the time stipulated for the completion of the work, will be proportionately increased or diminished.

All material used and all work done must be satisfactory to the City Engineer, and any work done or material used not satisfactory to said engineer shall be immediately removed and work and material of required quality substituted.

Pipe.—The sewer shall be constructed of vitrified clay salt-glazed sewer pipe, with socket and spigot joints and of the size and quality shown on the plans and herein specified.

The pipe shall be straight, smooth, sound, thoroughly burned and vitrified, well glazed and free from other imperfections, and of a thickness satisfactory to the engineer.

All straight pipe must be straight in the direction of the cylinder, and the inner and outer surface of each pipe must be concentric. The pipe is to be in length of not less than two (2) feet, and all pipes are to be made of good clay, well glazed, uniform in texture

and thoroughly burned, 80 per cent. of quantity to be less than one-fourth ($\frac{1}{4}$) inch out of round, and less than three-eighths ($\frac{3}{8}$) of an inch out of straight. No pipe is to exceed one-half ($\frac{1}{2}$) inch out of round or out of straight, and in no case is any pipe to be out of round on different diameters at different ends. The "curves" and "Y junctions" must conform to all the foregoing requirements as to quality, form and workmanship, and their thickness shall be equal to that of the pipe of the same calibre into which they may be worked or jointed. All branch junctions to be moulded on an angle of forty-five degrees with the sewer with which they are to connect. Junctions shall be put in at such places and in such numbers as the engineer shall direct. Proper increasers and decreasers are to be used to join different sized pipes where needed. When the trench is ready for laying pipe, the contractor shall give notice to the engineer to that effect, and no pipe shall be laid without the presence of said engineer or his authorized agents.

Pipes must be fitted before being lowered into the trenches. Pipes are to be laid in the best quality of American hydraulic cement. The inside must be wiped and freed from all mortar and left smooth and thoroughly clean throughout.

The ends of all branch pipes left for house or other connections are to be closed, by an earthen disk of similar material to the sewer-pipe used, and of a proper size, properly cemented in place, or by some other means satisfactory to and accepted by the engineer.

Equalizers.—At points on said sewer where junctions are necessary for private house connections, and where the depth of cut exceeds nine (9) feet, vertical pipes connecting with said sewer, and capped by breeches, shall be run up to within nine (9) feet of the street grade. Said pipes shall be placed at the points directed by the engineer, and shall be constructed in accordance with the plans therefor.

Manholes.—There shall be located, on the line of the sewer, nine (9) manholes, at points to be directed by the city engineer, in conformity with the plans adopted. Said manholes shall be oblong in shape, three (3) by four (4) feet at the base, and tapering in a two (2) foot circular hole at the top, and furnished with a cast iron cap and cover and catch bucket of the kind adopted in the accompanying plans. The bottom of manholes on pipe sewers are to be formed with brick, and it shall commence six (6) inches below the center of the sewer, and the interior of the bottom shall be formed to the exact size and shape of the lower half of the sewer. All manholes are to be carried up fully to the grade directed by the engineer. The bottom of the manholes shall be shaped into proper form with cement mortar in the manner ordered by and to the satisfaction of the engineer Proper steps made in accordance with the plans therefor, shall be built into the brick work of the manholes in position and number satisfactory to the engineer. Every manhole shall be fitted with a cast iron head and cap free from imperfections,

thoroughly cleaned and in dimensions and weight according to plan. Every manhole is to be fully completed and fitted with cover as the work progresses and as each is reached.

Catch-Basins.—There shall be located in said sewer district, four catch-basins at the points directed by the City Engineer in accordance with the adopted plans. They shall be thoroughly plastered with cement mortar on both the inside and outside. Said catch-basins are to be furnished with iron caps, and made throughout in accordance with the accompanying adopted plans.

Construction of Manholes and Catch-Basins.—Said manholes and catch-basins shall be constructed of sound, clear brick, clear from lime or cracks, set in the best quality of American hydraulic cement, and according to plans adopted and hereto attached. All brick are to be thoroughly wet by immersion immediately before laying.

All the masonry throughout, whether of brick or stone, shall be laid in cement mortar, made as described in these specifications. All mortar is to be made of the best American hydraulic cement, mixed immediately before being used with such proportions as the engineer may direct of clear, sharp sand, entirely free from foreign matter. To be thoroughly mixed dry, and when wet to be used before beginning to take the first set. The kind of cement used must be approved by the engineer. The proportions ordered of cement and sand are to be made by measurement and not by estimation. No greater quantity of mortar is to be prepared than is required for immediate use. Any excess left over at night, or that has been standing over two hours, shall not be re-tempered or used in any way. Mortar must be mixed in a proper box or on a floor, in no case upon the ground.

General.—The Contractor must strictly follow, without delay, all orders and instructions of the engineer or his authorized agents in the prosecution and completion of the work and every part thereof. The contractor, without a written permission from the engineer, is required not to sell, remove or permit to be removed from the line of the work, any sand, gravel or earth, excavated therefrom. But such sand, gravel or earth, shall be deposited at such places as said engineer shall direct. * * * * * * *

In case the contractor should abandon the work and refuse to commence it again within three (3) days after receiving a written notice to that effect from the engineer, or if he should fail to comply with the orders of the engineer, or these specifications, then the sureties on the contract shall be notified and directed to complete the work. In case the sureties fail to comply with the notice, the engineer may, within three (3) days, after serving notice, carry on the work at the expense of the contractor and sureties. In extreme cases the engineer may employ labor at the contractor's expense to perform work immediately necessary, either for the safety of the work or the public.

After the completion of the sewers and their appurtenances, should the engineer require it for his more perfect satisfaction, the contractor shall make such openings, and to such extent, through such part or parts of said sewer and appurtenances as the engineer shall direct; and he shall make the same good again to the satisfaction of the engineer. Should the work be found faulty in any respect, the whole of the expense incurred thereby shall be defrayed by the contractor, but if otherwise, by the party of the first part to to this agreement. The contractor shall keep the work in good repair for six months after completion; and correct and repair promptly during that time all failures of whatever description, and all settlements and irregularities which may occur in any road on the line of work, or any imperfect work upon sewers, manholes, or other structure; and shall deliver the work in all respects in good condition at the end of that time.

Records.—The following maps, plats, books, &c., are kept by the engineering department for office use and for reference:

(1.) Contour relief map.

A map has been constructed on a horizontal scale of 200 feet to the inch, showing the whole city in relief. A map was first constructed showing the contours of the city at two feet intervals, and each contour was traced off into heavy card-board, which was cut out to correspond with them. Beginning with a board of the size of the city on the scale taken, a layer of card-board was taken representing the lowest ground, then the card-board contour representing the next height was tacked on, and the map built up in that way. This map is found to be very useful in explaining different public works to the different committees, who as a rule can not understand a flat contour map.

(2.) A contour map showing 2 feet intervals.

(3.) A water map showing position of pipes, valves, gates, &c.

(4.) A sewer map showing position, size of sewers.

(5.) Street and property maps showing the manner in which the city gained or lost street or other property rights.

(6.) Assessment maps showing how special assessments were spread.

(7.) Plat books—showing all additions and subdivisions.

(8.) Monument map—showing position of monuments, marking position of streets, plats, &c.

(9.) Distance map, showing true distances between streets and of street lengths (Recorded plats do not show true distances).

(10.) Grade map, showing grades established.

(11.) A map showing position of gas lines is now under way.

(12.) Street profile book; scales used: horizontal, 200 feet = 1 inch; vertical, 6 feet = 1 inch.

(13.) Street grade book. In this in separate columns the following facts are noted:

1. Name of street on which grade is fixed.

2. From what point established.
3. To what point established.
4. Location of grade point.
5. Height of grade point above city datum.
6. Date when established.

(14.) Sewer profiles.
(15.) Sewer details.
(16.) Bridges and details.
(17.) Grades given.
(18.) Field books.

DISCUSSION.

Mr. Bell.—What is your method of setting curb-stones on streets running normal to sloping ground; do you set them at the same height on opposite side of street or not?

Mr. Mead.—It is impossible in some parts of Rockford to have the curbs at same height. In one case in Omaha where the distance between curbs was about 70 feet, there is a difference in height of about 4 feet.

Mr. Bell.—Were the gutters in Omaha at the same distance below the top of the curb?

Mr. Mead.—Yes, as I remember it. We found it necessary in Rockford to establish some grades of 1 foot in 18 feet.

Mr. Burnham.—I have seen the contour relief map of which Mr. Mead speaks, and it is a very interesting map.

Mr. Baker.—I think it would be a good thing for engineers who have to go before juries to consider such maps in relief.

Mr. Mead.—I have had the map before juries and both they and the judges could understand it much better than a contour map.

Mr. Baker.—Better never take a contour map before a jury expecting them to understand it.

MINE SURVEYING.

By F. V. ALKIRE, of Petersburg.

[Mr. Alkire had the misfortune to lose his manuscript on the above subject at the time of the January meeting. His paper was illustrated with drawings.]

DISCUSSION.

Mr. Balcom.—Are surveys of mines required by the state, and if so how often?

Mr. Alkire.—They are required to be made each year in coal mines.

————. Is that to prevent encroachment on other property?

Mr. Alkire.—Partly for that purpose and partly for the purpose of keeping complete records of mines.

Mr. McClanahan.—Is it not also partly for statistical purposes? Have you ever found a difference in activity or life of the needle at surface and at a considerable depth in the mine?

Mr Alkire.—I have found the needle so unreliable in a mine that I seldom use it.

Mr. Ela.—Have you ever found a creeping of the top or bottom of a mine?

Mr. Alkire.—I have known the entry to a mine nearly closed in 30 days by pressure causing the bottom to rise.

Mr. Ela.—There is one point I wish to call attention to regarding the law requiring annual surveys of mines and that is there no penalty attached for disobedience of the law, and it is not often enforced.

Mr. Braucher.—In regard to action of the needle, there is no difference in the life so far as I have observed, but it is never reliable in a mine because of local attraction.

Mr. Baker.—I think the needle is often unjustly blamed for being affected by local attraction. It makes no difference what the local attraction is, you can still measure angles with the needle as with a transit.

(Objected to by several members who did not understand Prof. Baker's assertion.)

Mr. Chamberlain.—If the needle is under the influence of local attraction will it always settle to the same position? In other words is not the local attraction at any one point liable to be a variable quantity?

Mr. Braucher.—I think the needle will always settle to same position at any one point in the mine, the local conditions remaining the same.

ARTESIAN WELLS.

By THEODORE B. COMSTOCK, of Champaign.

(Abstract.)

The question of pure water supply is annually becoming a more serious consideration to the people of Illinois, as well as to the citizens of other states. All classes should be interested in a subject of such vital importance to everybody. The mining engineer is particularly affected by that branch of the investigation which relates to deep-borings, and if he propose to extend his practice in this direction, he must soon acquire such knowledge as is available with reference to the buried lakes and water courses which which are eventually to be drawn upon for popular consumption.

The art of *well-boring* has made rapid strides within the last few years, thanks to the necessities and experiences in the oil regions; but the science of *well-seeking* has not kept pace with this progress, outside of this limited field. Many crude notions and wild theories still confront us and very little has been done as yet to collate and arrange the facts which have been ascertained. Professor T. C. Chamberlin (5th Annual Report U. S. Geological Survey, Powell, 1883–84, pp. 131–173) has done excellent service by putting "into a simple and convenient form such information relative to the necessary and qualifying conditions of artesian wells as may be capable of brief, general statement," and it is needless to add that he has done this in his usual admirable manner. He restricts the term "Artesian" to those wells which flow at the surface. Many persons very inappropriately place in this category all deep-seated supplies of water which have been tapped by borings. While this latter application of the term is wholly inadmissible, there is no necessity for removing the non-flowing (but *rising*) wells wholly from the artesian class. Hence the four recognized types of wells are grouped by different authorities in three ways, as follows:

I. (*Popular.*)		II. (*Chamberlin.*)		III. (*This Paper, Etc.*)	
1. Shallow,	*Surface.*	1. Shallow,	*Surface.*	1. Shallow,	*Surface.*
2. Flowing,	*Artesian.*	2. Flowing,	*Artesian.*	2. Flowing,	*Artesian.*
3. Rising,		3. Rising,	*Pumping*	3. Rising,	
4. Deep-Seated, Stationary.		4. Deep-Seated, Stationary.		4. Deep-Seated, Stationary.	Pumping.

Rising Wells (or those in which the water level is raised in consequence of the boring to a point below the surface) are not different from the flowing wells in any particular except that of escape at the orifice, which is a local condition not necessarily connected with the essential features of the main water conduit.

Chamberlin names seven "conditions upon which artesian flows depend."* Strictly speaking, however, we may include all requisites under four heads, viz:

First—A sub-stratum through which leakage is less rapid than the in-flow.

Secondly—A porous stratum directly or indirectly communicating with an area exposed to rainfall.

Thirdly—A roof-stratum sufficiently impervious to offer a resistance greater than the pressure due to the head of water in the supply-conduit.

Fourthly—Elevation of the source of supply above the level of the well orifice. This condition may be annulled by some other source of pressure developed in the interior of the earth.

It is a common but fallacious notion that artesian wells may be opened at almost any point by boring to very great depths. Although it is quite true that the local topography may have but trifling influence in determining success or failure in given localities, and that even the measure of the rainfall of restricted districts may afford no direct clue to their possible supplies of artesian water; and although the most reliable feeders are usually those which extend over very wide areas, the regions in which very deep wells are most successful are rather exceptional than otherwise. Besides, water which has penetrated to great depths is liable to be highly charged with mineral ingredients which may render it unfit for general use. There is a belief that this objection becomes less detrimental after a long period of flow. but not much reliance can be placed upon such hopes in most cases.

Those who best appreciate the nature and conditions of the artesian fountain-heads are least given to undertaking the sinking of trial borings without thoroughly ascertaining all that can be learned by the study of geological structure over wide adjoining regions. It is not enough to know that the first requisite is fulfilled, nor the second or the third and fourth. No artesian well is possible without the coexistence of all these conditions, and even with an apparent realization of the whole combination, there may be no chance of successful results.

1. *The leakage must be less than the in-take.* This proposition is self-evident, but it does not follow that the floor of the water bed is necessarily wholly impervious. Quite commonly the porous stratum is associated with half-pervious layers, and these may at times serve all practical purposes, by confining enough water for the demands which will be made upon the deposit. Sooner or later a dam will be found among the underlying strata. The question of

* 1. Pervious stratum. 2. Water-tight bed below. 3. Impervious bed above. 4. Inclination of these beds. 5. Suitable exposure of edge of porous stratum. 6. Adequate rainfall. 7. Absence of escape for the water at lower level than surface at the well.

practical importance is whether an abundant surplus be retained within the porous portion above. To determine this we must know the sources of supply and the character and structure of the rocks between these and the locality of the well. With admirable collecting ground and a free entrance to the conduit, not even a perfect retaining basin will be of avail without a conduit capable of transferring to the second a reasonably large percentage of what it originally receives from the first.

A stratum which is strictly imperious in one place may possibly become even porous a few miles distant, and the same bed may change from a compact, massive rock to a broken, highly fissured or thinly laminated bed. In order to decide just what good or bad effects such alterations have produced, one needs to be skilled in the field study of geology and in the interpretation of numerous minor problems which only long experience can enable the engineer to unravel, or even to observe correctly.

2. *The Porous Stratum must have free communication with a suitable Collecting Area.* Many of the erroneous ideas which have caused needless waste of labor and capital heretofore, are the legitimate crop from the text-book sowing of the familiar illustration, intended only to explain the simplest hydrostatic principle connected with artesian flow. But, in the large way, this example becomes misleading, for there is a variety of methods by which the results may be attained in nature.

*Starting with the synclinal trough (which is comparatively rare as an extended type of structure) with edges exposed to abundant rainfall, it will readily be seen that a persistent dyke following any course *not* normal to the strike of the fold, would divide the area into two distinct artesian reservoirs. If a second dyke should divide the whole area into three longitudinal parts, the middle portion would be cut off from both sources of supply, and no artesian well would be possible except upon the more elevated tracts upon the other sides of the dykes. In the first case, the erosion of one wall of the trough, in proportion to its extent, would affect the flow over the remainder of the region; and when but one slope was left, it would be completely drained by the escape of the water at the lower side of the tract. In the second and third cases, however, no effect whatever would be produced upon the uneroded slope until the dyke or dykes were removed. A similar influence is exerted by a dyke crossing even a moderate slope, so that upon the upper side the obstruction is essential to the existence of artesian wells, while it most effectually cuts off all chance of the same immediately beyond.

Dykes are commonly of different induration from the rocks which they penetrate; hence their presence is apt to be indicated at the surface by infallible signs, although this is not always the case.

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*This and other portions of this paper were illustrated fully by blackboard diagrams in colored crayon. It is impossible to reproduce these here, and the value of the paper, as printed, is considerably reduced by the necessary omission.

But there are other limitations of practically the same effect, which are not so easily discovered. A bed which is exceedingly porous at the collecting area may become more or less gradually impervious at an uncertain distance beyond, or it may thin out so that its upper and lower retaining walls may come together and act as a bar to farther penetration of the water. A mere "pinching out" of the porous layer for a very short distance might thus determine the boundary of a water deposit, notwithstanding the continuance of the "sponge" itself for miles in a dry condition.

Again, if the porous bed be cut through by a valley or gorge at any point, however remote from the fountain-head, so that the water can escape nearly as rapidly as it enters the conduit, the whole area above and below the outlet is practically barren, notwithstanding the coexistence of otherwise very favorable conditions.

3. *The covering strata must afford resistance enough to more than counterbalance the head of water in the conduit.* Impervious beds are not essential in the roof any more than in the floor, as all that is absolutely necessary is a sufficient excess of head to overcome the sum of the resistances to upward flow in the well. But with a non-pervious cap, this resistance is thereby limited chiefly to friction and pneumatic pressure in the well tube; whereas, if leakage occur through the roof, extra head is needed to make up the loss, and this in turn causes greater leakage due to increase (and in such cases, practically non-effective) pressure from the greater depth.

Professor Chamberlin has called attention to another important point in this connection which he has worked out conclusively in his field studies in Wisconsin.* Briefly stated, his view is that the height of the common ground-water between the fountain-head and the artesian well is often a more serious consideration than the imperviousness of the superincumbent strata. As it is somewhat rare to find the overlying rocks wholly impenetrable, owing to fissures, porosity, etc., a very thick capping is usually necessary to hold the water in a mass wholly separated from the surface water in the region of the well. This entails heavy loss and necessitates increased head, as we have already shown. In cases where the head is not great and the leakage is (comparatively) large, the question of success in boring is often quite dubious. But if the region between the well and the fountain-head be somewhat pervious and if the level of the ground-water be high, no leakage occurs; on the contrary the ground-water acts as an added resistance, tending by so much to increase the head in the conduit, and frequently makes artesian wells possible where they could not be had with a lower ground-water level. Thus a high water level between the inlet and the well orifice is a very favorable condition, and a partly pervious roof may, therefore, sometimes be a decided advantage. Instances are numerous in which from this cause, very nearly the theoretical flows have been obtained,

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*Geology of Wisconsin, Vol. I, p. 692.

the ground-water remaining at a higher average level than the fountain head.

4. *The source of supply must be at a higher level than the well orifice;* OR, *there must be a transfer of pressure (tension) from some other medium confined within the earth.* In regions of complicated geological structure and in those with quite horizontal strata, artesian wells are least liable to be produced. The chances are better, as a rule, in the latter than in the former areas. With such limitations to the statement as geologists will apply, this is almost equivalent to saying that the oldest crystalline and the latest formed sedimentary rocks do not present encouraging fields for prospecting in this branch of mining engineering. Yet, while the Archæan rocks as a capping may be set down as worthless, the Tertiary and recent strata can not always be so regarded, particularly if deep wells are practicable. Moreover, between these horizons, there are so many possibly favorable stages, that (barring other qualifying conditions which only the expert can determine in individual cases) the chances of success increase with the number of the geological periods represented in the section.

For reasons given under 2, *ante*, it is only in the smaller basins, usually in rather mountainous regions, that we need give close attention to more than the one slope upon which a proposed well is to be located. It is enough to be assured that there is no possible escape at a lower level within many miles and that between us and a higher exposure of the beds in a region of abundant rainfall, there is nothing to obstruct or to draw off the supply. Then, if all the foregoing conditions are carefully worked out by a competent engineer and if the boring be conducted by skilled labor under efficient and vigilant superintendence, the chances of failure will be reduced to a minimum.

Generally speaking, low inclination is preferable to a steep dip in the strata, because (1) erosion usually gives a wider exposure to beds but little inclined; (2) the wells will strike the deposit at less depth; (3) the water will be cooler and less impregnated with salts;* (4) the rocks will be more porous and usually less shattered; (5) there will be less danger from faulting of the beds; and (6) there will be less pressure upon the retaining beds, and hence less liability to leakage.

You will remember that I took radical ground last year in support of the opinion that the state of Illinois has a commercially valuable supply of natural gas entombed in her strata.† Careful study since then has only served to confirm that belief, and the predictions then made have been realized in so far as any developments have been made. There is a region in Iroquois and Champaign counties closely allied in position to the gas-belt, in which some very

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*This might need qualification in a paper of more detail.

†Oil and Natural Gas in Illinois. Paper read before Ill. Soc'y of Engrs. and Surveyors, January, 1887. Proceedings of Society, p. 92. Also reprinted in pamphlet form.

peculiar artesian wells occur. We cannot stop now to discuss these fully, but there seems very good reason to consider them and some other remarkable outbursts the results of the tension of confined gas so situated that it presses upon certain deposits of subterranean water in a way to force it out when vents are made for its escape. The wells near Gilman, which eject the water, are upon high ground, and their phenomena are wholly unaccountable upon any ordinary artesian well hypothesis, while the explanation here outlined appears to include all the facts observed, as well as others noticed in connection with a number of rising wells in the gas belt.

There are many more very interesting topics connected with this subject, which ought to be treated at length, but my present end has been gained, so far as the theory is concerned, if I have made you in some measure realize how wasteful and unreasoning is the present shiftless practice of locating expensive wells hap-hazard without regard to such principles as we advocate and apply in bridge-building, railroad work and municipal engineering. The boring of wells is a legitimate branch of mining engineering, for which only the mining engineer is well fitted, and especially is this true of the most important part, the location of the well.

Nor will I grant that the practical work of boring itself is now conducted as it should be in this state. There are men of experience, not mining engineers by title or training, except in this one line, who are capable of boring good wells quickly and economically. The best work yet done here has been what they have undertaken. But most of these men are rooted and grounded in oil-well practice, which—admirable as it is for its purpose—is not in all its details adapted to the sinking of artesian wells. It is not that the drilling needs modification, but the driller should better understand the signs of success and the relations of the results desired to the local circumstances under which he works.

The methods of drilling can not be now discussed for want of time, but there are a few points upon which engineers are not well informed, which should at least be mentioned in this place. Among these are the use and abuse of torpedoes, the employment of the seed-bag and other means of testing wells and the false conclusions which may be reached by incompetent observers. [Professor Comstock here illustrated several cases where erroneous results were obtained and showed how the correct solution might have been reached. He also described and illustrated a method of plugging a well by means of tubing surrounded by annular rubber discs, which, when pressed, expand to closely fit the irregularities of the boring, giving a water-tight joint. Some reference was made also to the method of drilling in the oil regions and to the importance of keeping records and of trained observation during the boring.]

We in Illinois are very deeply interested in this subject of artesian wells, for the future health and prosperity of the commonwealth are intimately associated with it. In that portion of the state north

of the Illinois River and particularly east of Dixon and La Salle, (speaking in a general way,) the main reservoir, sloping gradually from central Wisconsin and southward towards Chicago, lies not very far below the surface and good supplies of potable water may readily be obtained by artesian wells. Southward and westward the same beds are buried much more deeply, but new strata affording copious supplies of water overlie them. Some of this material is unfit for drinking purposes, some is highly mineralized, and other layers are capable of treatment which will render them potable. There is probably very little of the state wholly barren of artesian resources, but flowing wells may not always be obtainable. Very much added investigation is needed. The writer has been for three years collecting all available records and will continue to do so. He solicits notes and records from all the members of this society. In connection with the State Board of Health, a special study of the problems presented by our territory is being made with a view to a better understanding of our hidden water resources.

The wells at Streator, La Salle, Rock Falls, Morris, Rockford, Peoria, Beardstown, Litchfield and numerous other widely scattered points exhibit features of special interest, and the records serve to prove conclusively that we know far less of the geology of our state than is creditable to us.

It is to be hoped that legislators may be aroused to the vast importance of this subject, that they may be induced to appropriate liberally for a thorough economic survey in the near future. It would prove a most profitable investment to the taxpayers, to say nothing of its effects upon the health and comfort of the people at large.

EXECUTIVE SECRETARY'S REPORT.

To the President and Members of this Society:

The following is the report of the Executive Secretary for the past year:

DISBURSEMENTS.

Printing Annual Report	$217 00
Electrotype	8 50
Circulars, certificates and other printing	12 25
Express on reports	10 20
Postage	34 09
Stationery	4 35
Incidentals	4 85
Total	$291 24

RECEIPTS.

Advertisements	$208 00
Sale of Reports	7 70
From Treasurer	100 00
Total	$315 70
	291 24
Balance on salary	$ 24 46

A detailed report of the expenditures has been made to the Executive Board and may be seen by any one interested in it.

1,000 copies of the Second Annual Report were printed. Copies were sent to the Societies of Ohio, Michigan, Indiana, Missouri and Ontario. The exchange copies of these societies have been mailed to the members. New members and members who failed to receive these may obtain copies of the Secretary. There are also some extra copies of our Second Annual Report.

A movement has been started by the Ohio Society to make exchanges on a basis of cost of printing. This society should express its views on the question.

Before letting the printing contract the following bids were received:

H. W. Rokker, Springfield	$1 80 per page
Illinois State Register, Springfield	1 26 per page
Gazette, Champaign	1 28 per page

As the last firm was more conveniently located for the Secretary's work, and as it had given unusually good satisfaction in printing the first report, the work was given to the Gazette.

The Secretary is pleased to report that the receipts from advertising are so large. The result was obtained only by persistent soliciting. It is to be hoped that the members will show their appreciation of this generous support by patronizing these firms whenever possible.

The papers published in the last report have been very favorably received, several of them being copied into engineering and scientific journals. Nearly all of the papers were mentioned in the index of the Journal of the Association of Engineering Societies. A number of applications for membership have been received. Still it is evident that the state of Illinois has scores of competent engineers and surveyors who have not joined. The efficiency of the society largely depends upon the size of the membership. The movement for mining engineers is meeting with success, and at the next meeting a special session can be devoted to them. In like manner it is hoped that by another year the number of railroad engineers will be so large that their interests will receive more papers and a separate session. More papers on land surveying had been planned for this meeting, but in several cases no answers or else refusals were received.

The Secretary regrets to announce the death, Dec. 31, of R. N. Johnson, of Norris City, a charter member. Only a few days before, he was at work upon a paper for this meeting. Mr. Spencer, who for some years has acted as his deputy, has prepared a sketch of his life, which will be read during the session.

A. N. Talbot, Executive Secretary.

TREASURER'S REPORT.*

To the President and Members of this Society:

The following is the report of the Treasurer to January 26, 1888:

RECEIPTS.	
Balance in treasury at close of 2nd annual meeting	$77 70
Membership and assessment fees received after that meeting	75 00
Total	$152 70
DISBURSEMENTS.	
Executive Secretary, on bill for printing annual report	$100 00
Balance in treasury	$52 70

Geo. P. Ela, Treasurer.

*This does not include money received and disbursed at the meeting.

REPORT OF EXECUTIVE BOARD.

To the President and Members of this Society:

We would report that we have examined the books and accounts of the Treasurer of the Society and believe them to be correct; also the report and accounts of the Executive Secretary, which have been laid before us.

In order to meet the expenses of the Society for the ensuing year, including the cost of publishing the annual report and the salary of the Executive Secretary as voted by the society, we make an assessment of $4.00 each upon old members, and of $2.00 each upon all members who join during the present year. We also recommend that, in order to facilitate the collection of dues and payment of bills, the Executive Secretary be elected Treasurer of the Society.

C. G. Elliott, Chairman.

REPORT OF THE LEGISLATIVE AND JUDICIARY COMMITTEE.

To the President and Members of this Society:

The members appointed on the regular committee were also appointed by the president as a special committee to conduct the application for legislation recommended by the Society at its second annual meeting and this report will serve for that of the standing and the special committee.

At the second annual meeting the Society recommended several changes in the laws of the state as being just, both to the surveyor and engineer, and for the best interests of the public.

Your committee after consultation and comparison thought best to advance only one change in the laws, namely, the law in regard to the land surveyor. The bill finally introduced into both house and senate of the legislature is hereto attached. The bill met with opposition, not by the public who are supposed to be chiefly interested, nor yet by the surveyor whose interests were partially affected, but by the political demogogue; and as the last mentioned article has much to do with the conduct of the legislature, his opposition was effective. The arguments against the said bill could be capitulated under the following heads:

(1). A state board of examiners would add to the political machinery of the state.

(2). No present necessity exists for the appointment of said board.

(3). Possibility at some future time of the state having to assume the expense of the board through the liberality of favorable legislatures.

It was noticed by your committee that the architectural association of the state had introduced a bill establishing a system of examination for architects who desired to practice their profession in this state. The bill in general plan was not materially different from ours. The same arguments were urged against that and with the same success.

The committee called to its assistance the President and several members of the Society who labored with commendable zeal for the passage of the bill. The committee could not, however, obtain from the members of the Society any concerted action. Many members of the Legislature whom we would like to mention advocated the measure and ably worked for its adoption.

The bill failed to pass; no change at all being made in the laws affecting the engineer and surveyor.

The committee would call attention to a few facts made noticeable during their work. No work can be accomplished in this direction without previous and active work from all members of the Society. The bill affected only those members of the Society directly interested in surveying, and it was with difficulty that other members could be induced to make active effort for it. What is to the interest of the Society is for the interest of all, and all should steadfastly advocate it.

We suggest that literature be systematically distributed on this subject and the whole membership consistently advocate the improvement of our laws. Care should be taken that only valid arguments and fair illustrations be used so that nothing would be objectionable to any one. Systematic, persistent effort should be followed, and unless all should enter into the effort nothing should be undertaken.

S. A. BULLARD, Chairman.
Z. A. ENOS.

A BILL

For An Act to provide for the examination and appointment of licensed surveyors.

SECTION 1. *Be it enacted by the People of the State of Illinois, represented in the General Assembly*, That the Governor of the State of Illinois shall nominate and (by and with the consent of the Senate) appoint three surveyors who shall be commissioned as licensed surveyors, to be called "the State Commissioners for the Examination of Surveyors," to be selected from the best practical surveyors of the State most distinguished for their scientific and practical knowledge of surveying, one of whom shall be appointed to hold his office for two years, one for four years and one for six years, respectively, from the first Monday of July, A. D. 1887, and until their successors shall be appointed and qualified. And during the month of January, A. D. 1889, and every two years thereafter, the Governor, by and with the consent of the Senate, shall appoint one Commissioner, to be selected from the most skillful and experienced of the licensed surveyors, as hereinafter provided for, to fill the place of the Commissioner whose term of office shall expire on the first Monday of July thereafter. And it shall be the duty of said Commissioners, or a majority of them, to meet at least once in Springfield and once in Chicago, within the first year after the passage of this act, and at least once a year thereafter at some place to be by them designated, notice whereof shall be given for twenty days preceding the time of said meeting in a newspaper published in the county where the said meeting is to be held, to all persons desirous of obtaining a license to survey, of the time and place of said meeting. It shall be the duty of the said Commissioners, or a majority of them, to examine and pass upon the qualifications of all applicants for said license, and to certify to the Governor the names of such applicants as they may find to be thoroughly qualified in the theory and practice of surveying, and who shall have produced satisfactory proof of strict integrity and moral character; and thereupon it shall be the duty of the Governor to issue a commission, under seal of the State, to each of said applicants so certified to, licensing and empowering them as surveyors, to survey in any and all parts of this State, and to do and perform all acts in relation to surveying the same as county surveyors are now or may be hereafter authorized to do by the laws of this State.

§ 2. Each surveyor commissioned as aforesaid, before proceeding to survey, shall take and subscribe to an oath, before some clerk of the circuit court or county court in this State, that he will in all things, faithfully and impartially perform the duties of surveyor to

the best of his skill and abilities, which oath shall be endorsed on his commission; and said commission shall be entered of record in the recorder's office of each of the counties of this State in which said surveyor shall make surveys, and a certified copy of said record shall be evidence in all courts of law and equity, without producing or accounting for said original commission.

§ 3. Each licensed surveyor as aforesaid, shall, before making a survey of any tract of land, provide himself with a copy of the Government plats and field notes thereof, and with such other recorded evidence of survey as may be necessary to his purpose, and shall make his survey in conformity thereto, and to the acts of Congress, and to the statutes of Illinois governing the same, and he shall be authorized and required to administer to his chainmen and flagmen the necessary oath for the faithful and proper performance of their respective duties, and he shall be empowered to administer and certify any oath required to be taken by commissioners for the assignment of dower, or the partition of real estate, or by any commissioner or reviewer to mark, locate or re-locate any public highway or private road, and to take the evidence, and to incorporate the same with his survey of any person who may be able to identify any original government or other legally established corner, or witness thereto, or Government line tree, whenever such licensed surveyor may be in doubt as to its identity or verity.

§ 4. All chainmen, flagmen, and other necessary hands, in any survey, shall be furnished by the person for whose benefit such surveying is done, and they shall be good and disinterested persons, to be approved by such licensed surveyor.

§ 5. All surveys and proceedings had and done by said licensed surveyor under and by virtue of this act, shall be held and taken to be *prima facie* correct; and all plats and certificates thereof under the hand of said surveyor, shall be received in evidence in all courts of law and equity in this State, and be entitled to be entered of record in the recorder's office of the several counties thereof; but no such plat or certificate made by such licensed surveyor, or by any county surveyor, of any subdivision of land, or any new street, highway or alley, within any incorporated city or town, shall be so recorded until it shall be first approved by the proper authorities of said city or town.

§ 6. The circuit court of the county where any surveyor commissioned under the provisions of this act may survey, shall have power to annul said commission upon satisfactory evidence being presented of the incompetency or misconduct of such surveyor, said surveyor having been duly notified to appear in his own defense. And upon such annulment and notice thereof from said court, the Secretary of State shall cancel the same and mark the date of such canceling upon the records in his office.

§ 7. Each applicant for license under this act shall pay into the hands of said commissioners the sum of twenty dollars as a fee.

The commissioners shall pay from the fund so established all the expenses necessary to fully carry out this act, including their own necessary expenses while actually engaged in the discharge of their duties. The said commissioners shall not allow to themselves any other compensation or emolument: *Provided*, that any candidate who may fail to pass an examination shall be entitled to a second examination not less than six months nor more than one year after such failure, without further payment therefor.

§ 8. The said commissioners shall meet within thirty days after this act goes into effect and organize. They shall elect one of their number treasurer, who shall make a bond of amount to be determined by the said commissioners to be approved by the Governor, and file the same in the office of the Secretary of State. And annually during the ten days preceding the first day of January the said commissioners shall make a report to the Governor of all acts performed by them, and account for all funds placed in their hands.

DISCUSSION.

Mr. Ela.—I did not advocate the passage of the bill, because there was no penalty attached affecting surveyors who practiced without license.

Mr. Braucher.—I think we have no right to dictate to a man who shall survey his land. I like the bill as it stands.

Mr. Wright.—There are two classes of surveys, those which only affect the individual and those which affect the public. I believe that public surveys should be made only by competent men and the law should dictate who is to make them. I think the penalty law would have a tendency to improve the standing of the surveyer.

Mr. Enos.—In the bill which we presented it was not so much a question of what we liked but what we could get that would be better than the present conditions. We tried to eliminate all features that would be objectionable to the legislators.

Lawyers will not preclude evidence because not given by licensed surveyors.

Mr. McClanahan.—There is today not a penny of public money paid to surveyors. As the law now reads anybody can be classed as a competent surveyor. This bill is with a view to elevate the profession.

Mr. Bullard.—Being the youngest member of the committee, I was in favor of a more stringent bill. I wanted to get to the top of the ladder at once, but the older members saw that we could not do that. This bill was intended for the first few rounds in the ladder.

Mr. Enos.—There was a few years ago an excellent law, but owing to incompetency of surveyors operating under it and ignorance of lawyers regarding laws governing surveys the law was brought into ridicule and was repealed.

REPORT OF THE COMMITTEE ON LAND DRAINAGE AND PUBLIC HIGHWAYS.

To the President and Members of this Society:

Drainage.—All engineers are obliged to take into account natural forces, using all of those which can be made available, for the purpose of counteracting those which oppose themselves to the construction of such works as are economic and necessary to financial progress. For instance, the railroad engineer must take into account the influence of varying temperature on the strength of metals, the corroding action of the forces in the atmosphere which affect the strength and longevity of wood, and the action of climate upon different varieties of brick, stone and cement. The hydraulician must take into consideration the resisting power of clay and the effect of ice and floods on structures which come within the province of his work. This state of things obtains to a greater or less degree in all branches of the engineering profession, and the uncertainties of climatic forces occasion no little solicitude on the part of every one who has the planning of any extensive work. In the work connected with drainage engineering we must work against soil and weather in some cases, and with these same forces in others. The uncertainties of wind and weather, of evaporization and the capricious behavior of varying soils are sometimes enough to perplex those of large experience and skill in drainage work.

The drouth which has prevailed throughout the state during the past year has given rise to very sharp discussions and to the recording of much observation upon the question whether land drainage is the cause of the drouth. It has given the opposers of land drainage abundant opportunity to air their theories and point to the dry weather of the past year in proof of their correctness. While much has been said on both sides of this question which partakes altogether too largely of mere assertion, we may sum up some points which we believe are substantiated by reliable investigations, the details of which we cannot spread out in this brief report.

1st. Does general land drainage decrease local rainfall? By consulting the existing records of rainfall of this country, covering with greater or less thoroughness the last fifty or sixty years, we find that periods of drouth and corresponding periods of excessive rainfall have prevailed, and that the drouths have been more severe in some instances than the one we have just passed through. Not only do tabular statements of precipitation show this, but the recollections of old inhabitants corroborate it. All of this only shows that extremes of drouth and precipitation were as common and as uniform

before any drainage was done, as have been observed since. At the same time it must be admitted that the rainfall of the interior of any country is very variable with respect to time and quantity, and that the laws governing its precipitation are not formulated. The breaking up and cultivation of wild prairies, both in this state and in the west, have been accompanied by additional rainfall. To such an extent is this so, that there are areas in the west which were formerly nearly rainless, but now yield, under proper cultivation, sufficient produce to support an increasing population.

2nd. Does the drainage of land decrease the quantity of moïsture which is held in the soil during a time of drouth?

For experiments to determine this point, we are indebted to the agricultural department of our State University, under whose auspices much valuable matter is being collected and disseminated. From the data furnished on this point we draw the following conclusion: The absolute quantity of moisture which exists in an underdrained soil in time of drouth is no less than that found in an undrained soil, while the tilth of the soil, and general condition of vegetation is much better in the former than in the latter.

We find that the interest in improving and reclaiming large areas of land is not abating, but that general farm drainage has fallen off very materially during the past year. Our state law, when faithfully adhered to and carried out, is giving good results where cooperative drainage is desired. Though the law is faulty in some particulars, yet the failure to secure good results from its operation is owing principally to the cupidity, and in many cases ignorance, of commissioners and land owners upon matters over which they have control.

Looking at our subject from a professional standpoint, we may observe several points of interest.

In the first place there is a good prospect for a continued demand for the drainage of large tracts of land, hitherto worthless. It is demonstrated beyond a doubt, that the investment of capital in such projects will pay a larger interest than equal investments in manufacturing enterprises, provided the land to be drained is rich in natural fertility. With such prospects it becomes every engineer who is devoted to this branch of the profession to investigate all undetermined problems connected with the work in order to reduce the practice of draining to a determinate basis. This knowledge will be required of engineers in the near future, yes, more, it is demanded now.

The chairman of your committee proposes to begin experiments during the present year to determine by actual measurement the flow of water in tile drains and canals, and to compare the amount with the acreage and rainfall for the purpose of obtaining the ratios in different cases, a matter we believe to be very important to the profession and the public.

We recommend, that, in making surveys and plans for drainage either of farms or districts, a topographical survey be made, and that

sufficient data be taken to determine the water-shed lines and total elevations and that the whole work be reduced to a common datum. The ultimate economy of this plan of work will appear when we come to locate drains and adjust matters between different land owners, which must be done in cases of organized drainage districts.

We note with much satisfaction the improvements made in steam dredges for ditch construction. The introduction of these machines makes it possible for the engineer to design drainage work with some degree of assurance that it will be executed in a creditable manner, instead of in the slipshod and inefficient way which seemed to be a necessity a few years ago.

Public Roads.—In the matter of public highways we can report no material progress. We note that in some townships the repair of the roads is placed in charge of one man who devotes all of his time, or as much of it as the funds in the treasury will warrant, to the care of the roads under the general supervision of the Commissioners of Highways. This plan is in much favor where it has been well tested. In some localities where stone is accessible, permanent arch bridges and abutments are being constructed. In other places there is a contest between the iron bridge and wooden bridge parties, the adoption of either kind depending upon the color of local politics and not upon the economic value or advisability of the work in question.

We think that the cutting up of the state by our progressive railroad systems will, in due time, help to solve the permanent road question by making it possible to transport stone and gravel for surface covering. In the meantime it will be to the interest of engineers to keep their eyes open to every advance in the science of road making and be ready to help the work on when the opportunity for so doing is given.

In noting the condition of road affairs in our own state, we will, for the purpose of exciting emulation, refer to the new course of instruction adopted in the Vanderbilt University at Nashville, Tenn. This covers especially the science of making and maintenance of public highways, and, as we understand it, is opened for the instruction of highway commissioners and other officials connected with the public road system. The term extends through the months of February and March, and instruction is given by lectures. It remains to be seen whether the interest in that state is sufficient to fill these classes or not, but it is certainly to be hoped that such is the fact.

C. G. Elliott, Chairman.

REPORT OF GENERAL COMMITTEE OF ENGINEERING.

To the President and Members of this Society:

We will first call attention to an outline of work which if faithfully worked out in detail by your committee would have given the society a valuable report. Although the committee has fallen far short in doing thoroughly this detail work, it is hoped that the report may have some points that will meet with favor, and we must plead a pressure of business on all members of the committee for not doing better.

The following outline of work for the General Committee of Engineering we hope may be of some assistance to committees of the future:

1st. Call attention to important engineering works begun, finished or contemplated during the year, giving references to such plans and descriptions of same as have been published.

2nd. Discuss briefly such topics of general interest to the engineer as call for a general expression of opinion or a concert of action among engineers as a body.

3rd. Call attention to new publications and papers read before the various societies, which are of especial interest to the profession.

4th. Call attention to any general progress made in engineering methods or work.

5th. Call attention to branches of engineering in which improvement in methods or work is badly needed.

6th. Call attention to failures of engineering works or projects.

ENGINEERING WORKS.

Under the 1st division we call attention to the New Croton Aqueduct at New York as one of the great engineering works now in progress in this country, the work on which has progressed rapidly during the year. In connection with this work it was decided last February to build the "Quaker Bridge Dam," which will be much the largest work of the kind in the world. It is to be built across the Croton valley and in cross-section will be 22 feet wide at top, 216 feet wide at bottom, and 265 feet high. The reservoir it will create will hold 32,000,000,000 gallons of water. The report of the Croton Aqueduct Commission and special report of Chief Engineer Church on Quaker Bridge Dam gives full description and plans of these works.

An undertaking that is attracting the attention of the world is the Eiffel Tower at Paris, which is to be 1,000 feet high. Work on

this is in progress, the excavation for foundations having been begun in the early part of last summer.

Work has been in progress on that colossal undertaking, the Panama canal, to which another reference will be made later.

We refer to a few of the great bridges recently completed, in progress, and contemplated:

One of the largest and highest bridges of the world is the contilever bridge now in process of construction at Poughkeepsie over the Hudson. It will cost about $5,000,000 and when completed will have an immense railroad traffic.

The Harlem river bridge is in process of construction and will probably be completed within a year.

Work is progressing on the greatest bridge of the world—the Forth bridge in Scotland. This great cantilever bridge dwarfs the greatest completed bridge of the world, our Brooklyn suspension bridge.

As an example of rapid bridge construction we mention the Lachine bridge over the St. Lawrence at Montreal. It is one of the prominent cantilever bridges of this country, and is highly complimented for the artistic treatment where passing from a deck to a through bridge. Of the four principal spans two are 408 feet each and two are 266 feet 4 inches each. Total length is 3,535 feet. This bridge was built in 12½ months, being completed in the latter part of 1886.

One of the large bridges in process of construction is that at Cairo, Ill., over the Ohio river. Both St. Louis and Memphis are talking of bridging the Mississippi river in the near future.

The proposed North River bridge, to conduct the traffic of ten railroads into New York city, is to have six tracks, with provisions for adding four more; it is to be a stiffened suspension bridge with two spans of 1500 feet each and one span of 2800 feet. If built, it will dwarf all other bridges now built or being built. A comparison of this with others of the greatest bridges of the world is interesting. The Forth bridge of Scotland, a cantilever, has two spans of 1700 feet each and two of 675 feet each. The great Brooklyn suspension bridge has one span of 1595½ feet and two of 930 feet each. The Poughkeepsie cantilever bridge has 3 spans of 548 feet each and two of 525 feet each. The great steel arch bridge at St. Louis, the smallest of this lot, has one span of 552½ feet and two spans of 537¼ feet each.

The arrival on December 9, 1887, of engineers from the United States on the field of operations for the survey of a route for the proposed Nicaraugua canal, encourages us to think that this country may have control of the canal or ship railway which it is hoped will in a few years connect the oceans.

The introduction of a bill in the present congress to create a Lakes and Gulf Water-ways Commission, to be composed of two army engineers and three civilians, suggests the possibility of a great en-

gineering undertaking which may have a marked influence on the internal commerce of the country. The proposed commission is to make surveys and examinations with a view to connecting the lake at Chicago with the Mississippi river by way of the Desplaines and Illinois rivers. If such connection should be made and the proposed amount of six hundred thousand cubic feet of water be emptied per minute from the great lakss into the Illinois river and thence into the Mississippi river, it would at low stages be an immense advantage to the navigation of those rivers. Before jumping to the conclusion that such a connection would be a good thing, however, we would better pause to study the effect it would have on high stages of those rivers, and also the effect on stages of rivers connecting the great lakes. So far as we know there are not sufficient data to determine with any certainty what these effects would be, but it is possible that their defects would offset the advantages gained. We trust that the commission will make a thorough investigation of these questions before taking steps to execute such work.

Much important government work was stopped or much retarded by the pocket veto of the river and harbor bill passed by the last congress. Some of the work of the past year is worthy of notice, however, as having a bearing on possible works or results of the future.

The continuation of surveys and study of tidal currents of New York harbor, is of interest to the entire country, as aiding in the study for future improvements of our most important harbor.

The work of bank protection along the river front of Greenville, Miss., made during the past year will quite probably have an important bearing on future government works on the Mississippi river. If this work stands, it is quite probable that the system there used will largely take the place of bank revetment. If it fails, it will demonstrate that the system is at fault. The system used is a series of dykes of willow mattresses extending from top of the bank to a point well out towards the middle of the river, each dyke being weighted by stone and at center by a heavy crib extending its entire length. All work has in this case been made extra heavy and has been carefully done, so if it fails it will be the fault of the system.

The work of building a sill near the head of the notorious Atchafalaya is in progress. This work is with a view to prevent the increase of water carrying capacity of the Atchafalaya, which seems to threaten the eventual deflection of the entire Mississippi river down its channel.

ENGINEERING QUESTIONS.

The present state of the United States' treasury presents very favorable conditions for the inception of government engineering projects. With a surplus that is alarming statesmen, there seems to be no excuse for delay in beginning needed internal improvements, coast defenses, harbor improvements, &c. The fact that the country is in a prosperous condition and with a large treasury surplus is un-

questionable proof that it can well afford to make vast improvements. Any material reduction of the revenues by a tariff reduction will, in the opinion of many, work to the detriment of the country, and is at best likely to prove a doubtful experiment. Our internal water-ways and harbors should have far more liberal appropriations than they have yet had, while many of our coast harbors can be improved with advantage. In many of our larger towns and small cities the public service would be benefited by the erection of postoffice or custom house buildings. Money should be spent liberally upon defenses for our important harbors and sea-board cities. Our navy should be strengthened, and an attempt made to build up a merchant marine which could be called into government service in case of need.

With the possibility of such improvements in view, the question of *The Relation of Army and Civilian Engineers to Public Engineering Works* suggests itself. That the present relation is unjust in many cases to the civilian engineer, no fair-minded person can deny. But looking at it impartially, would it not be equally unjust and contrary to the laws of political economy to confine the army engineer to such works as pertain to army engineering proper at times when such work will not keep the corps busy. Should the government undertake all needed works, the question would easily be solved. The coast and internal defenses would probably keep the army engineers busy, and the river and harbor work would be left for the civilian engineers. Should the river and harbor work fall to the civilian, it is to be hoped that a system will be adopted by which engineers may be appointed for their engineering rather than their political qualifications.

There is a bill before congress for the purpose of creating a Bureau of Harbors and Waterways, officered by a corps to be known as the Corps of United States Civil Engineers, to consist of 1 Chief, who may be an army engineer, 4 Associates, two of whom may be army engineers, 9 or 11 Department Engineers, 5 of 9 or 6 of 11 may be army engineers, Division Engineers not to exceed 50 in number, 20 of whom may be army engineers, 1st Assistant Engineers not to exceed 100 in number, 2d Assistant Engineers not to exceed 200 in number, and Cadet Engineers not to exceed 250 in number; the corps to have charge of all harbor and water-way improvements. The bill seems to give a fair division of work between army and civilian engineers.

The question of appropriations for public works is of especial interest to engineers. That the present system of making or attempting to make annual appropriations is pernicious, is proved by the effect of the stoppage of important works at critical stages, due to failure of congress to make sufficient appropriations, or, to veto of the bills by the President. These stoppages often result in almost total destrnction of the work, and always in an unnecessary expense in reorganizing parties to resume the work, and often an expensive deterioration of plant while idle. It seems quite possible that the

present congress will adopt a different system. In case they do not, engineers should not cease to make war upon the present system until a reform is effected.

The subject of a closer union of the engineering societies of the country is still under consideration by a number of societies. The Board of Managers of the Associated Engineering Societies at their last meeting decided to bring before the societies the question of holding a convention of delegates for the consideration of forming a confederation or other union of such societies. This has not met with favorable action from some of the societies. The desirability of a confederation is questionable, since some of the local societies have members who are not engineers. A joint system of publication might be of great benefit to the profession. In case such a system is not adopted, there should be instituted a systematic method of exchange, in order to bring society publications before as many engineers as possible.

ENGINEERING PUBLICATIONS.

In this division time has allowed but a very limited list of the more important publications of the year.

A work of much interest to railroad engineers is that of Wellington's Economic Theory of Railway Location, published by John Wiley & Sons, of New York.

The Croton Aqueduct Commission of New York have given an interesting report in the form of a large quarto volume containing many illustrations and plans of many structures including the Sodom Dam and the Quaker Bridge Dam. Of special interest is the special report of Chief Engineer Church on Quaker Bridge Dam.

A work of considerable interest is the report on the Final Results of the Triangulation of the New York State Survey, with monographs by O. S. Wilson and others on the methods employed.

The Forestry Division of Department of Agriculture in their Bulletin No. 1 have given an interesting report on the Relation of Railroads to Forest Supplies and Forestry, referring particularly to the question of railroad ties.

About one year ago the government published a list of all its published documents. This work is for sale by the government. It is valuable to engineers, since they will now be able to know of the many valuable works on river and harbor improvements, geological, geodetic, topographical and exploration surveys, weather reports, valuable astronomical and other tables, and translations of some very valuable works of foreign engineers, many of which have been unknown to a majority of the engineers of the country.

ENGINEERING PROGRESS.

Coming to the fourth division of our work we are glad to note much progress in engineering methods and work during the past year.

A general tendency towards more substantial construction in railroad practice is seen. Heavier rails, more ties per mile, preservation of timber by chemical treatment, replacement of wooden with

iron and iron with stone structures, and a general increase in weights of engines and rolling stock seems to be the tendency. There is also a marked movement in the east toward the abolition of highway grade crossings. The Latimer-Childs system of bridge guards, guard-rails and re-railing devices is being adopted. The adoption of a standard automatic coupling for freight cars is recommended by the Master Car Builders' committee. Several systems of heating trains by steam from the engine have been put in successful operation.

Advancement has been made in the application of electricity to lighting trains. The train used by President Cleveland, during his recent trip, was lighted by a dynamo driven from the car axle, using a storage battery as a reservoir while the car was at rest.

Great improvement in train brakes has been made. The tests made at Burlington, Iowa, during the last year show that the improved brakes of Westinghouse, Carpenter & Eames surpass all previous appliances. In the tests of the Westinghouse improved air brake on a special train made at various points, they have eclipsed all previous records.

Rapid transit in cities has been receiving much discussion during the past year. "The horse-cars must go," is the cry, and as a result we see elevated roads, electrical roads and cable roads taking their place. In many parts of the south, dummy trains are the favorite. Electricity as a motor for street railroads is attracting much attention. At the beginning of the past year this country had a total of about 33½ miles, divided among 9 cities and towns. By the middle of the year 16 other cities and towns had electric roads under way with an aggregate mileage much greater than all previous roads of the kind in the country.

The cable system is meeting with much popular favor in several cities and a large mileage has been added to the system during the year.

Elevated roads have not been so successful in establishing themselves, a large proposed mileage in Philadelphia and St. Louis being defeated by opposition of property owners. A mammoth scheme for elevated roads in Chicago is proposed, the roads to run in all directions from the business center, the fare to be 3 cents with transfer to any part of city for 1 cent additional.

Electricity as an illuminant and coal as a fuel are threatened with some strong opponents. The oil gas process is the latest, and if it proves its claims there will be a revolution in heating and probably in lighting cities. The gas is formed by a very simple and inexpensive method from a crude petroleum which cannot be refined and which is found in immence quantities in Ohio. It is said that it can be purchased for 25 cents per barrel. The gas can be produced at a cost of one-half that of coal gas, and it gives a much greater heat and a more powerful light. Darby, Pa., has used the system for lighting and heating with excellent results, during the year past. St. Paul has recently determined to adopt the system, and other cities are investigating it.

As an illustration of the powerful opponent that coal has in natural gas we cite the assertion that in Pittsburg and Allegheny City the gas takes the place of 200,000,000 bushels of coal annually. If the reports prove true that Chicago can get natural gas in her vicinity, and that there is unquestionably natural gas under the city of St. Louis. we may expect to see a change of fuel in those cities.

The use of natural gas is not unattended with danger. It appears that China once had a natural gas craze, until a terrific explosion made an inland sea of a large section of country, killing several millions of people. We cannot refrain from here appending the "Startling Prediction" of the Fireman's Herald. In commenting upon the Chinese catastrophe, it says:

"The same catastrophe is imminent in this country, unless the laws restrict further development in boring so many wells. Should a similar explosion occur in this country, there will be such an upheaval as will dwarf the most terrible earthquakes ever known. The country along the gas belt from Toledo through Ohio, Indiana and Kentucky, will be ripped up to a depth of 1,200 feet to 1,500 feet and flapped over like a pancake, leaving a chasm through which the waters of Lake Erie will come howling down, filling the Ohio and Mississippi valleys and blotting them out forever."

NEEDED IMPROVEMENTS.

A very lengthy report might be made under this division, but as engineers are on the alert making improvements in every department of engineering, we will abridge this part and enter a protest against combustible bridges on railroads whereby the lives of the traveling public are endangered; and we also make a protest against any method of bridge designing whereby the joints are so hidden from view as to render inspection difficult or impossible. The Bussey bridge failure is an example of such pernicious practice.

ENGINEERING FAILURES.

It is not a pleasant task to treat of engineering failures. Numerous railroad accidents, resulting in some cases in a fearful loss of life, caused by poor construction either of track or bridges, point to so many engineering failures.

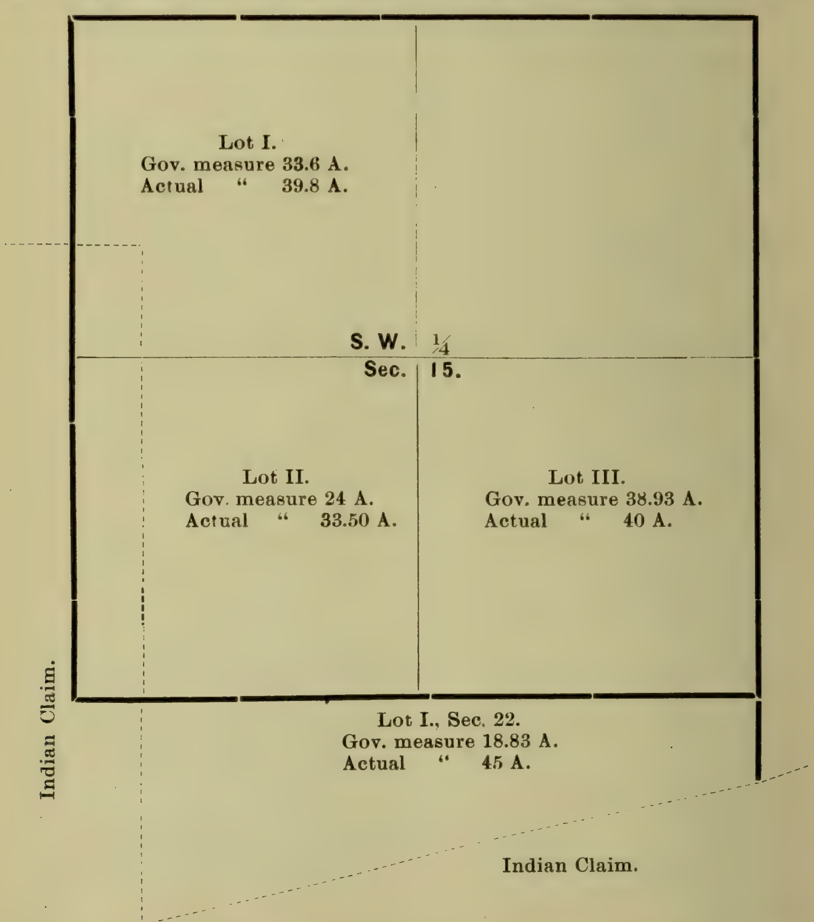
The failure of the Chatsworth trestle is an engineering failure none the less because it was weakened by fire. The Bussey or Tin bridge was an engineering failure due to bad designing and construction. Many other failures could be enumerated, but we will pass to the consideration of that colossal undertaking, the Panama canal, which in all probability is soon to be recorded as a colossal engineering failure,—a failure for want of money to continue work, but none the less an engineering failure in that the engineers' estimates of cost were not approximately correct. We cannot be expected to lament greatly, as it improves the status of our contemplated enterprise, the Nicaraugua canal scheme.

C. W. CLARK, Chairman.

REPORT OF COMMITTEE ON LAND AND CITY SURVEYING.

To the President and Members of this Society:

Question: The government sells the lands shown on the sketch, the description reading, lots I., II. and III. of section 15, and lot I. of section 22. The Indian claim, previously deeded and described by



metes and bounds without reference to section lines, has its lines run from identified monuments. Will the excess of land in the two sec-

tions without the lines of the Indian claim belong with the lots, or will the title convey only the specified acreage of the lots?

Answer: The excess belongs with the lots. Lot II. covers all of S. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$, Section 15, not within actual limits of Indian claim, without regard to excess or deficiency. The same with the others.

Question: What is the best position for monuments?

Answer: On all county, township and section lines, at proper corners, with the auxiliary use of witness monuments when possible. In cities and towns the outside corners of the land laid out should have monuments. Interior block corners, 10 inches diagonally outside of corner stake, and driven or sunk deep.

Question: Methods of overcoming obstacles in city surveying

(*a*) Where no monuments exist?

Answer: Do the best you can.

(*b*) Where there is an excess or deficiency in block over recorded plats?

Answer: Divide *pro rata.*

(*c*) Where the lots are sold by metes and bounds and there is an excess or deficiency over the deeded land?

Answer: The original seller owns what is left in block or is responsible for full area to purchaser.

[Exception taken by several members.]

Question: In questions *b* and *c* should priority of deed govern?

Answer: No.

Question: What conditions should guide the surveyor in laying out new additions?

Answer: First find some undisputed point in the adjoining old part of the city or town from which to commence the survey, and then make the addition correspond as nearly as possible to the old, connecting the two by accurately measured distances between points in new and old. Make and have recorded an exact plat. This plan should also be followed in all subdivisions of blocks.

THOMAS S. McCLANAHAN, Chairman.

REPORT OF COMMITTEE ON MUNICIPAL ENGINEERING.

To the President and Members of this Society:

The tendency of most branches of the civil engineering profession is to specialize. Hydraulic engineering, sanitary engineering, railroad engineering, and the many other subdivisions of the profession, necessitate the special examination of one class of facts and give all others a subordinate position. With municipal engin-

eering alone this is not so. The province of the municipal engineer is almost as broad as the profession itself. It includes the design, construction and maintenance of all the various public works which the comfort, convenience and safety of an urban community demand, and is only limited by the limit of urban necessities. It includes the duties not only of the officer commonly called the city engineer or city surveyor, but the duties of all those officers having the care of the public works of a city. This subject is a hard one to deal with; for not only is it diversified in its extent but the conditional circumstances of each municipality modify all the variety of details and must qualify every conclusion drawn from local successes or failures. Experience is always the great teacher, and where the experience of others can be utilized many mistakes and their consequent failure may be prevented.

It is thought desirable to collect as many facts as possible in connection with the various municipalities, in order that the local practices and details may be compared. These practices should be given with sufficient general information to enable all to understand the reason of their successes and failures. In order to accomplish this we would recommend that each member of this society be requested to write a description of the corporation in which he lives, using the points given in the appendix to this report as suggestions for the form. These articles should be sent to the committee, who by this means may be able to do work of great practical importance. There is also appended to this report an article of this kind concerning the city of Rockford, Ill.,* which is offered with the hope that it may be of some value to engineers of other cities.

Daniel W. Mead, for Committee.

APPENDIX TO REPORT.

SUGGESTION FOR DESCRIPTION OF MUNICIPAL ENGINEERING PRACTICE.

Liberal extracts from city laws or ordinances concerning the control of public works should be made, and a map showing the city's topographical features should be given with such other drawings as will illustrate special features. The fact should be remembered that points which are the most common and apparently insignificant in one city are often of great value in a comparative view of the place. Generalities can be gathered from many encyclopedias, dictionaries and treatises, but the minor points of practical application are very seldom treated at length.

Information on the following subjects is desirable: The name of the corporation; county and state in which located; latitude and longitude; when founded; when incorporated; area embraced; hight of lowest land above sea-level.

Temperature. Statistics of rainfall, giving information of especially heavy showers in amount, duration and rate.

*This article will be found on page 102.

The number of inhabitants at present and for periods dating back as far as possible.

The topography of the country. The geology of the country.

Valuation of property at present and for previous year. The date of the beginning of the municipal and fiscal year. The legislative body of the corporation and their control on public works. The executive head of public works. The executive officers of the city, their authority, term of office, duties, subordinates, salary, and how appointed. The manner in which public works are paid for, by general tax, by special taxation, or by special assessment. Extent to which each is used and how the system works.

Limits of the annual appropriation; when made. The annual expenses for each department, such as water-works, sewers, pavements.

Number of miles of streets in the city, their width. Is any portion of the streets seeded to grass? General width of alleys. The length of street that has been paved or improved by the different methods. Position of city datum. Establishment of a system of grades. Principles used in the establishment of grades. Sidewalk grades established, how related to street grades. The usual cross-section of the street. Arrangement of the gutters. The manner and methods of cleaning streets. How and at whose cost are streets watered. Are trees planted in the streets? By whom cared for, what kinds? How are ashes and garbage, &c., removed? At what expense? Are there any parks; number, size; drinking fountains, public fountains, urinals?

What style of bridges are used, describe them, give capacity, &c.

System of water supply used, thorough description, where obtained, how controlled, &c., for what used. Average consumption of water. Miles of mains, number of fire hydrants, rental. Analysis of water. Describe reservoirs, filters, &c.

Describe sewer system with details, lowest grade of sewers, least depth, method of ventilation.

How are streets lighted; number of lamps; annual expense; on what schedule is the city lighted?

Give system of house numbering. City records. Any other information in relation to the management and control of the public works.

REPORT OF COMMITTEE ON MINING ENGINEERING.

To the President and Members of this Society:

The Standing Committee on Mining Engineering have the honor to report that they have pursued the policy of the previous year, making vigorous efforts to enlist the cooperation of the mining engineers of the state in the objects of this society. The circular sent out to all whose names could be obtained, has elicited favorable responses from many and we have been pleased to present the names of a good number of applicants for membership, whose influence and counsel cannot fail to be of great value to our organization. Another year we trust that not a few important papers on mining topics will be read before you.

No questions of serious moment have arisen in mining matters since the last meeting of the society. Such labor troubles as have menaced the peace in the eastern coal field have long since been happily settled, and whatever complications may result in future from present business relations, the adjustment is apparently satisfactory for the time being. We can rejoice at the absence of accidents and the generally safe condition of the mines of the state under our efficient system of inspection. While legislation has not yet gone far enough, some advance was made at the last session of the legislature. The Mine Inspectors have all been induced to join this society and we shall thus be able to get the benefit of their intimate knowledge of the needs of both miners and mine-owners under existing laws.

The mineral product of the state is slowly but steadily increasing, and better than this, more perfect and less wasteful methods are gradually being adopted. Among the improvements of late years are the crushing and grading of coal as now practiced at Bloomington by the McLean County Coal Co., the washing of coal for coking in the southern part of the state, the introduction of machine coal cutters, and the employment of the most approved tools in the boring of deep wells. Still, there are many mines in which the modern and thoroughly tested systems of haulage and the most economical plans of working are not adopted. Drainage and ventilation are apparently good on the average, though not always as skillfully arranged as might be, perhaps.

The resources of the state are still too little known and we believe it to be quite demonstrable that our supplies of coal, cement, iron ores, fire-clays, and even oil and natural gas, in addition to artesian water, are far in excess of what is generally believed. A liberal legislative appropriation of funds for the clear exposition of the

mineral wealth of the state would prove highly remunerative and very largely develop the mining industries.

Large additions to the capacity of the plants adapted to the reduction and refining of ores and their products have recently been made. At the last session of the legislature, an appropriation was made for the erection of a mining and metallurgical laboratory in the University of Illinois, at Champaign, where a number of students are now being trained for future careers as mining engineers. This year a complete testing laboratory will be started, to be followed by a full set of apparatus for determining the quality and proper modes of working the various minerals mined in Illinois.

On the whole, we feel that the mining outlook is quite favorable and that the opportunities for good mining engineers are annually becoming more numerous and encouraging. The public is awakening to the importance of accurate mine surveying, heretofore an almost neglected branch of engineering, and by means of its revelations the attention of mine-owners is gradually being drawn to the glaring defects in some of the present loose methods of mining.

We have succeeded in getting some special papers prepared for this meeting, and we conclude with the hope that our humble but earnest work may eventually bear more abundant fruit than is as yet apparent.

Respectfully,

THEO. B. COMSTOCK,
A. C. BRAUCHER,
F. V. ALKIRE,
} Committee.

REPORT OF COMMITTEE ON INSTRUMENTS.

To the President and Members of this Society:

We take pleasure in saying that without solicitation the firm of A. S. Aloe & Co., of St. Louis, Mo., have made a very fair and creditable display of engineers' instruments, such as transits, levels, compasses, drawing instruments, paper, &c.

We would make special mention of their transit and level. These instruments are fully up to the time in all modern improvements and show careful workmanship in their construction.

The committee would also suggest that engineers and surveyors requiring instruments, supplies or repairs would do well in giving this firm a trial.

GEO. M. CLARK, for Committee.

REPORT OF COMMITTEE ON NATIONAL PUBLIC WORKS.

To the President and Members of this Society:

Your committee on National Public Works would respectfully report that they have received a communication from the Executive Board of the Council of Engineering Societies on National Public Works, suggesting that a meeting of the council will probably be called some time in February and requesting this society to send a delegate. The Secretary also desired to be informed of the numerical strength of our society, and the facility with which we could call an extra meeting if one was deemed necessary by the council to secure our ratification of any important question requiring the action of the various state and local engineering societies.

As a matter of general interest to our profession, your committee would call attention to the introduction of a bill in the United States Senate, January 16, by Senator Cullom, of this state, for the establishment of a Bureau of Harbors and Waterways, to be a branch of the War Department.

"HARBORS AND WATERWAYS.—SENATOR CULLOM'S BILL FOR A NEW BUREAU IN THE WAR DEPARTMENT.

WASHINGTON, D. C., Jan. 16.—Senator Cullom introduced a bill today for the establishment of a Bureau of Harbors and Waterways in the War Department, to be officered by a corps of United States civil engineers. The proposed bureau is to be charged with the construction, conduct, and preservation of harbors and water-ways. Its personnel is to be: One chief of corps, four assistant chiefs, not less than nine nor more than eleven department engineers, and not more than fifty division engineers; 100 first-assistant engineers; 200 second-assistants; and 250 cadet engineers. The country is to be divided and subdivided into grand divisions, departments, and divisions, over which the officers provided for will have charge. The pay of these officers is to be as follows: Chief Engineer, $10,000; associate chiefs, $7,500; department engineers, $6,000; division engineers, $4,000; first-assistants, $2,700; second-assistants, $1,800; and cadets, $1,000, with the privilege of retirement on half-pay at the age of 65. The chief and half of the associate chiefs, department and division engineers, may be appointed from the Army Engineer Corps, with the option of resuming their place in the military service at any time within two years. No appropriation for work, the bill provides, shall be expended unless it be sufficient to complete the work, or unless provision shall be made for funds necessary for its completion. This provision, however, is not to apply to dredging or snagging operations or to works of a temporary nature, the purpose being stated to be to prevent the ex-

ercise of discretion by the engineers when they know that the amount appropriated is insufficient to serve any useful purpose."

Upon the appearance of the above in the public journals, your committee addressed an inquiry to Senator Cullom asking what objections there would be to making the proposed bureau an independent department of National Public Works, and in reply received the following:

"UNITED STATES SENATE, WASHINGTON, D. C., Jan. 21, 1888.

Geo. P. Ela, Esq., Springfield, Ill.:

MY DEAR SIR: Your favor of 18th inst. is received and noted. I have no information yet as to what the probabilities are with reference to the bill introduced by myself, as it has just got to the committee and has not been taken up and discussed at all. I should think it would be somewhat doubtful whether my bill, or such a bill as you suggest, could be passed at the present session of congress, as the legislators are a little slow in favoring any measure the result of which would create any departments or bureaus requiring the appointment of many additional public officers. I should doubt whether the present session was the right time to press a measure of that kind.

There is much force in what you say as to the necessity of separating the public works of the country from the present departments as they now exist.

With respect, I am, very truly yours,

S. M. CULLOM."

Your committee consider the passing of this or a modified bill of similar import of very great importance to every member of our profession.

Your committee would recommend that this society place itself on record as in full accord with the object of the council and that we send a delegate to next meeting of said council.

GEO. P. ELA, Chairman.

REPORT OF COMMITTEE ON EXHIBIT AND EXCHANGE OF DRAWINGS.

To the President and Members of this Society:

Your committee appointed at the Springfield meeting make the following report:

The society was unanimous in its estimate of the value of an exchange of drawings. For most of our members such an arrangement will furnish plans and information not otherwise obtainable. Notwithstanding the multitude of books, few treat of the structures

most needed in every day practice, and generally those few are so tardy in their appearance and are so deficient in detail that their value is greatly impaired. Only works of considerable magnitude reach the light. Monographs and illustrated articles on the great engineering works of construction such as the St. Louis bridge, the Croton aqueduct, etc., are published, but few can expect to have the opportunity to design such structures and their publication is of little interest to the majority of engineers.

What is needed is clear, concise information concerning the smaller structures found in every locality, together with the special method of overcoming difficulties in each particular instance. An important item is the matter of details. The city engineer wishes to see detailed plans of catch-basins, manholes, culverts and small bridges, the floor system and foundation of bridges, the cross-section of paved streets, position and height of curbstones, methods of changing grades at intersection of streets, etc. The railroad engineer will be interested in plans of common pile and trestle bridges, rail sections, cross-sections of standard roadbed, switches, station buildings, peculiar track locations, plans of bridges and culverts. The drainage engineer can furnish maps showing economical location of ditches and drains and methods of overcoming special difficulties. For the land surveyor, questions of location of land lines that have been decided in court or otherwise, matters in dispute, or problems of general interest in making surveys can be shown by a drawing. And so for the different divisions of the profession. Any member can find at least some one thing in his practice during the year which will be of value to the members. Novelty is not always essential; and designs that may seem commonplace or unimportant to the designer may fill a want of many members. The New England Water-works Association have in this way secured a collection of drawings that are of great value, and the Connecticut Society of Engineers have used the method with success. If the members will give their individual aid to the scheme, it will become one of the most profitable features of our society.

Your committee have decided on the following general plan: Members are requested to send to the committee tracings, or other kind of negatives, of such drawings as they may deem of value for this purpose. A list or catalogue of all drawings received will be sent to the members as soon as enough are secured. A blue-print copy of any drawing on this list will be sent to any member on receipt of price equal to actual cost of making the prints. This in general will be about five cents per 100 square inches of the drawing. Besides this sale of special drawings, the committee will make a general distribution among the members of such prints as may be of general interest. All tracings will be reserved as the property of the society.

The committee will also endeavor, if desired by any member, to secure drawings on any subject or work not contained on the list.

Negatives.—Members and friends of the society are requested to furnish tracings or drawings of all engineering works, maps, bridges, water-works, sewerage works, railroad construction, location of mines, machinery for mines, problems in drainage location or land surveying—in fact, any feature of interest in railroad, mining, municipal, drainage, or general engineering. Every member ought to furnish at least one drawing during the year. These should be sent in at an early date, in order that members may have the use of them during the coming season. Photographs of engineering works, or even the address of the photographer with a description of the view are also solicited. The names of individuals or companies furnishing drawings will be catalogued with the drawings.

Size, etc.—For uniformity and in order that the drawings may not be too bulky, the regulation size has been made 10×15 inches. Only drawings of considerable importance should be made larger than this. Members ought to be able to donate enough time to the society to reduce one drawing. Those on hand are larger, but in the future an effort should be made to keep to the regulation size. Drawings should have enough descriptive matter on them to enable them to be thoroughly understood.

Cost.—The cost to members will be the same as the actual cost to the society. It is estimated that this will be five cents per 100 square inches of drawing.

In conclusion we wish to urge upon members the desirability of having these drawings for the society. Let each one set about to furnish a tracing. If a member knows of a drawing of a structure that will be of unusual interest to the members and there is no tracing, the committee will endeavor to arrange to secure it. The full exhibit of drawings at the Springfield meeting will give members an idea of what can be done in this line. With proper support, we hope to make this exchange of drawings a successful feature.

A few plans have already been donated. A list of them is appended and also a short description by Mr. Mead of the process of making blue prints and similar reproductions.

A. N. TALBOT,
S. F. BALCOM, } Committee.
D. W. MEAD,

LIST OF DRAWINGS.

Iron beam bridge at Rockford, 18×24 inches.
Skew bridge, 35-ft. span, 20-inch I-beams.
Manhole—Cap, cover and catch-pail, as used at Rockford, 18×26.
Small pile drivers for driving sheet piling, 18×24.
45-ft. truss girder—railroad, 19×25.
Details for 45-ft. truss girders, 19×25.
Wooden beam bridge, 20-ft. span 18×24.
Wooden trestle viaduct, Rockford, 9×9.

Sewer flush tank, 10×15.
Middletown catch-basin, 10×15.

ENGINEERING PHOTOGRAPHS,*

with size and price, including postage. The same unmounted will be 5 cents less.

	Inches.	Cts.
Chicago, Madison & Northern R. R. bridge at Rockford, Ill. 6 spans, 135 feet each	14×17	75
Mmasonry on above bridge—5 views	8×10	40
Temporary trestle for construction train over Kishwaukee River, C., M. & N. R. R.—2 views	8×10	40
Otis & Chapman Excavator, with dump cars at work in C., M. & N. R. R.—2 views	8×10	40
Pile driver at work on bridge piers	5× 8	25
Laying 16-inch water pipe across the Rock River at Rockford—2 views	5× 8	25
Winnebago County Court House; cost $215,000	8×10	40

REPRODUCTION OF DRAWINGS BY THR BLUE-PRINT PROCESS.

When a number of copies of a drawing are desired, the various processes of solar or "sun" printing will be found to be the cheapest and most rapid. These processes are based on the fact that certain chemical salts or combination of salts when exposed to actinic rays of light change their composition, some becoming colored. some losing color and some becoming insoluble.

If paper be treated with these chemicals and exposed to the light, the chemicals on the parts exposed undergo this change, while parts not exposed remain unchanged. If a drawing be made in dark lines on a transparent or translucent medium or in transparent lines on an opaque medium, and prepared paper be exposed to the light under such medium, the light will act through the transparent portion of the medium and produce the change on the prepared paper. The mediums are usually styled "negatives."

The blue process is the process in most general use and ordinarily is the most successful. In this process opaque lines or parts of the drawing remain white, the paper turning blue where the negative is transparent. Hence an ordinary tracing will copy as white lines on a blue ground, while an ordinary photographic negative will copy positive; i. e., blue lines on a white ground. The remaining description may need some modification for other than the blue-print process.

Negatives.—Negatives may be made in a variety of ways.

1st. The drawing may be photographed and the common photographic negative obtained, or silver prints may be obtained from the photographer who makes the negative.

The negative in this case is limited in size to that of the largest camera which is accessible. The drawing when photographed can be enlarged or reduced. Usually when preparing a drawing for a photographic negative it is better to make it large and reduce it, as in this way a clearer cut negative can be obtained.

* For sale by O. H. Wheat, Rockford, Ill.

2d. A tracing can be made on tracing paper, parchment paper, or tracing cloth directly from the drawing,

If after making the drawing in pencil the tracing cloth or paper be placed over it and the inking be done directly on the cloth or paper, no extra work is required in making the tracing. Care must be taken to make the tracing just as desired in size and in width of line, and all errors must be carefully avoided as all will be faithfully reproduced in the copy.

3d. Drawings can be made on the thinner kinds of paper such as bond paper or on parchment paper mentioned above and used directly as a negative.

The helios paper, a translucent paper otherwise much the same as ordinary drawing paper, can be obtained of dealers. Excellent blue prints may be made with it.

In all drawings or tracings made either for photographing or for negatives, care must be taken to have the lines perfectly black or non-actinic. Brown, vermillion, or yellow added to the ink will help it considerably. The writer has found the liquid color, burnt sienna, to work admirably as an ink.

Printing Frames.—Printing frames are ordinarily made with plain wooden sides, with glass front and wooden back. Plate glass is preferable but double thick glass of good quality, free from bubbles and spots and of even thickness, will answer. It is better to have the back of the frame in two pieces so that the progress of the printing may be examined from time to time. The back should be pressed against the print by means of springs or other device. The back should be padded with a layer of cotton flannel or thick woolen cloth. A good idea of how to make a printing frame may be obtained by examining the photograph printing frames. Very large prints may be made by tightly stretching the tracing and prepared paper over a large cylinder, which should be then placed on bearings and slowly and uniformly revolved in the light; by this method prints of any size can be made in one piece. Usually, however, large prints can be made in several sections of ordinary size and pasted together.

To Sensitize.—The sensitizing bath for the printing paper is made as follows:

A { Citrate of ammonia and iron, 1 part.
water, 4 parts.

B { Red Prussiate of Potash, 1 part.
water, 6 parts.

Dissolve A and B separately at ordinary temperature, and set in the dark until needed. When wanted for sensitizing, mix A and B in equal proportions and apply to the paper.

Sensitizing must be done by lamplight or in a darkened room under yellow light. To sensitize, lay the paper on a board and apply the solution with a soft, wide brush or soft sponge. After the paper is covered, go over again until no lines can be seen, always brushing

in the same direction. The paper should then be hung up to dry in the dark and carefully kept from the light until used.

To print.—The negative is first put in the frame next the glass: on this is laid the sensitized paper with the sensitized surface next the negative; then the padding and lastly the back of the frame is put in and pressed firmly down to hold the sensitized paper tightly against the negative. Expose to direct sunlight from three to twenty-five minutes, or in diffused daylight (on cloudy days) from one to two and a half hours. Experience will soon teach the amount of exposure necessary.

After the prepared paper has been sufficiently exposed under the negative the print is removed and placed either in a tank of running water or on a flat board under a faucet of water and thoroughly washed until all the unchanged salts have been removed. The print is then hung up until dry.

White lines on blue prints may be obliterated by applying some of the sensitizing solution and exposing to light and washing. White lines may be drawn with either white ink or with a solution of potassium carbonate in water (40 grains to the ounce). Common soda in solution will give good results.

Paper.—Paper for the copying processes should be heavy, white and well glazed, although almost any paper will do. Where bibulous papers are used, gum arabic must be added to the sensitizing solution to prevent the liquid from soaking through the paper. Paper already sensitized can be obtained of the various wholesale dealers in drawing materials and will keep for several months if carefully protected from the light. Silver paper, such as is used by photographers, already sensitized can also be obtained Although silver prints are expensive they are very sharp and clear.

There are several other processes for solar printing but the above gives the best satisfaction for ordinary work.

OBITUARY.—R. N. JOHNSON.

R. N. Johnson was born December 16, 1836, near where the village of Norris City now is, in White County, Illinois. He was given a good common school education. While in his minority he commenced teaching public school, continuing until elected County Surveyor of White County in 1879.

His father, J. J. Johnson, in early life was a resident of the State of Tennessee, where he combined the practice of surveying with that of teaching school. Having a considerable knowledge of land surveying, he gave his boys practical lessons in surveying with the compass and chain. The subject of this sketch soon distanced his brothers in his proficiency, and attained considerable notoriety in his locality as being skillful in tracing old lines, and was often called upon to settle disputes and locate lines before he began his official career.

In June, 1886, he was appointed on the U. S. Geological Survey and was assigned to the work in Arizona under Professor Thompson. Leaving the work in his county in charge of his deputy, he went to his field of labor, but was soon compelled to resign on account of ill health, and in the following December returned home. He died of pneumonia December 31, 1887, after an illness of only two days. The funeral ceremonies were conducted by the Masonic fraternity, of which he had been a member for over 25 years.

He had served as Surveyor of White County for 8 years, as township school treasurer for 20 years, and as town clerk for 9 years. He was a man of known integrity and uprightness of life. He had fewer enemies than is usual with men thrown in contact with the public, and it can be truthfully said that he was almost universally respected and beloved. He leaves behind a wife and seven children to mourn his loss.

M. W. Spencer.

Norris City, Illinois.

RESOLUTIONS.

The following report was made and unanimously adopted:

Your committee appointed to draft resolutions on the death of R. N. Johnson respectfully submit the following report:

Whereas, Death has removed from us our esteemed friend and co-laborer in the Illinois Society of Engineers and Surveyors, R. N. Johnson, thus taking away an able and earnest member; therefore,

Be it Resolved, That the Illinois Society of Engineers and Surveyors deeply sympathize with the bereaved wife and family of the deceased, in the taking away of a loving and devoted husband, a kind and wise father, a noble and good, yet unassuming citizen.

That a copy of the above resolution be transmitted to the family by the Secretary of the Society.

Geo. M. Clark, Chairman,
George P. Ela,
A. H. Bell,
Committee.

NOTICE OF FOURTH ANNUAL MEETING.

The fourth annual meeting will be held in Bloomington, Ill., in January, 1889. The local members have promised a cordial welcome to the city of brick pavements, and the local attractions will be numerous. An interesting and profitable meeting is assured. The healthy growth of our society warrants the statement that our members are realizing the advantages of a connection therewith.

In order to give the various branches of the profession sufficient time, the society may be divided into two or more sections, and certain lines of work will be given on separate days. In this way members interested in only one branch need not remain for the whole session.

MUNICIPAL ENGINEERING

Attention is called to the series of articles on the cities of Illinois which is proposed by the committee on Municipal Engineering. The article on Rockford shows the value of such a series. These descriptions, together with the standard plans, will give the engineers of our small cities much desirable information not otherwise attainable.

DRAINAGE ENGINEERING AND SURVEYING.

The society is of especial value to those engaged in land surveying and drainage in that those topics are not included in the field of the usual engineering society or periodical. These members are urged to give their individual aid in making the next programme attractive. Much value can be derived from an exchange of problems and the discussion of the replacement of lost corners under special circumstances. Several papers for this branch were promised for the last meeting, but were not received.

MINING ENGINEERING.

A number of mining engineers and metallurgists have joined, and it is proposed to devote a special session to their interests. The mining engineers are asked to make this feasible and to increase their membership.

RAILROAD ENGINEERING.

Several papers of interest to this department have been given, and more attention will be devoted to it in the future. To the younger members, especially, of this branch of the profession, membership offers many advantages, and it is hoped the number will increase.

EXHIBIT AND EXCHANGE OF DRAWINGS.

Attention is called to the plan for the exchange of drawings as given in the report of the committee. Proper support by the members will make this a valuable feature.

The exhibit of drawings at the Springfield meeting was a successful beginning of that plan. Members are requested to bear this matter in mind and to increase the exhibit for next year.

MEMBERSHIP.

Applications for membership may be received at any time, thus allowing the applicant the advantage of the proceedings of the present year. The addition to our numbers at the last meeting was large, and it is desired that many more of the same calibre become members

REPORT

—OF THE—

FOURTH ANNUAL MEETING

—OF THE—

ILLINOIS SOCIETY

—OF—

ENGINEERS AND SURVEYORS,

—HELD AT—

Bloomington, Ill., January 23-25, 1889.

PRICE FIFTY CENTS.

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GAZETTE STEAM PRINT.

1889.

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Committee on Land Drainage and Public Highways—D. J. Stanford, E. I. Cantine, Geo. V. Loring.

Committee on Land and City Surveying—H. C. Niles, Jacob A. Harmon, Samuel S. Greeley.

General Committee on Engineering—Prof. I. O. Baker, S. F. Balcom, D. W. Mead.

Committee on Mining Engineering—Prof. T. B. Comstock, Thomas Hudson, F. K. Copeland.

Committee on Municipal Engineering—A. H. Bell, Geo. F. Wightman, Frederic Rottman.

Committee on Instruments, Blanks and Records—T. S. McClanahan, L. N. Sizer, J. O. Wright

SPECIAL COMMITTEE.

Committee on Exhibit and Exchange of Drawings—S. F. Balcom, S. A. Bullard, D. W. Mead.

MEMBERS.

W. W. ABELL .... Elgin.
City Engineer.

FRANK V. ALKIRE .... Petersburg.
Deputy County Surveyor.

THEADORE A. ALLEN .... Mattoon
Chief Engineer, P. D. & E. Ry.

*A. S. ALOE .... 300 N. 4th street, St. Louis, Mo.
Mathematical Instrument Maker.

JOHN W. ALVORD .... 69 Ashland Block, Chicago
Civil Engineer.

I. O. BAKER .... Champaign
Professor of Civil Engineering, University of Illinois.

S. F. BALCOM .... Champaign
Assistant Engineer, I. C. R. R.

A. H. BELL .... Bloomington
City Engineer and Drainage Engineer.

CLARENCE BRAINARD .... Buda
Civil Engineer.

A. C. BRAUCHER .... Lincoln
Mining Engineer.

D. L. BRAUCHER .... Lincoln
Civil Engineer and Surveyor.

S. A. BULLARD .... Springfield
Architect and Sanitary Engineer.

J. W. BURNHAM .... Bloomington
Agent King Iron Bridge Co.

J. S. BURT .... Henry
Surveyor.

JOS. E. BURTLE .... Pawnee
Engineer and Surveyor.

E. I. CANTINE .... Bloomington
Civil Engineer.

C. W. CLARK .... 2828 Washington Ave, St. Louis, Mo.
U. S. Assistant Engineer.

G. M. CLARK .... Low Point, Woodford County.
Drainage Engineer.

J. L. CLARK .... Momence.
County Surveyor and Civil Engineer.

W. D. CLARK .... Springfield.
City Engineer.

E. J. CHAMBERLAIN .... Pittsfield
Engineer Sny Island Levee Repairs.

* Associate Members.

S. C. Colton..........217 E. Ohio street, Chicago.
Engineer with The Fitz Simons & Connell Co.

T. B. Comstock..........Champaign
Professor of Mining Engineering, University of Illinois.

F. K. Copeland..........22 W. Lake street, Chicago.
Vice President Di mond Prospecting Co.

J. K. Croswell..........Kankakee.
Civil Engineer and Surveyor.

D. H. Davison..........Minonk.
Surveyor.

G. W. Dickinson..........Shelbyville.
County Surveyor, Shelby county.

John H. Diers..........Sibley.
Drainage Engineer.

George Dixon..........Alton.
City Engineer.

Nicholas DuBois..........Springfield.
Civil Engineer and Accountant.

Joel Dunn..........Bement.
Drainage Engineer.

G. P. Ela..........Bloomington
Surveyor and Civil Engineer.

C. G. Elliott..........Gilman.
Civil and Drainage Engineer.

Z. A. Enos..........Spr ngfield.
Surveyor.

Jacob T. Foster..........Chicago.
County Surveyor and Civil Engineer.

James Freer..........Peoria.
State Mine Inspector.

G. W. Gastman..........Hudson.
Surveyor.

Daniel Gordon..........Moline.
County Surveyor and Civil Engineer.

Richard Gray..........Bloomington.
Civil Engineer.

Samuel S. Greeley..........60 Bellevue Place, Chicago.
Surveyor and Civil Engineer.

Charles Hansel..........Springfield.
Engineer Wabash R'y.

Jacob A. Harmon..........Milford.
County Surveyor and Civil Engineer.

J. M. Healey..........Champaign.
Divis on Engineer I. C. R. R.

E. A. Hill..........Cincinnati, O.
Real Estate Agent, C. I. St. L. & C. R'y.

S. N. Howard..........834 Opera House Block, Chicago.
Surveyor, and Secre'ary Greeley-Carlson Co.

Thomas Hudson..........Galva.
State Mine Inspector.

O. Jones..........Cambridge.
County Surveyor.

WILLIAM KILGORE..Rose Hill.
County Surveyor, Jasper County.

J. S. LANE..Chicago.
General Superintendent M. C. Bullock M'f'g. Co.

JOHN R. LEWIS.. Piper City.
County Surveyor and Civil Engineer.

GEORGE V. LORING..Decatur.
County Surveyor and Civil Engineer.

T. S. McCLANAHAN..Monmouth
Surveyor and Civil Engineer.

D. McNABB ....Tonica.
Surveyor.

DANIEL W. MAHER..324 Burling St., Chicago.
Assistant Engineer, Dep't. of Public Works.

D. W. MEAD..Rockford.
City Engineer and General Manager Rockford Construction Co.

ARCHIBALD MEANS..Peru.
Zinc Manufacturer.

E. L. MORSE..Cazenovia.
Civil Engineer.

JAY C. MORSE..302 First National Bank Building, Chicago.
President Union Steel Co.

L. B. NEIGHBOUR..Dixon.
County Surveyor and Instructor in Civil Engineering in Northern Illinois Normal School.

H. C. NILES..Tuscola.
Surveyor and Civil Engineer.

JAMES F. PARR..DeSoto, Mo.
Engineering Dept., St. L. & T. B.

ETHAN PHILBRICK..Western Springs.
Ass't Eng., Chicago & Alton R. R.

GEO. W. RICHARDS..Carthage, N. M.
Ass't Mining Engineer and Sup't., San Pedro Coal & Coking Co.

FREDERICK ROTTMAN..LaSal'e.
City Engineer.

EMIL RUDOLPH..50 Wisconsin St., Chicago.
Surveyor.

WALTON RUTLEDGE..Alton.
State Mine Inspector.

GEORGE F. SAMUEL..Chicago,
Ass't Eng., Dep't of Public Works.

A. C. SCHRADER..Joliet.
Civil Engineer.

W. S. SHIELDS..69 Ashland Block, Chicago.
Civil Engineer and Surveyor.

L. N. SIZER ....Mahomet.
Drainage Engineer.

D. J. STANFORD..Chatsworth.
County Surveyor and Civil Engineer.

HUBERT A. STEVENS..145 Loomis Street, Chicago.
Assistant Engineer, Department of Public Works.

A. N. TALBOT..Champaign.
Assistant Professor of Engineering and Mathematics.

C. H. TRYON .... Greenwood.
County Surveyor.

HENRY T. WALSH .... Buffalo.
County Surveyor.

GEO. K. WHEELOCK .... Normal Park.
City Engineer.

E. H. WHITAKER .... Peru.
Drainage Engineer.

NOAH WHITLEY .... Joliet.
Civil Engineer.

GEO. H. WHITTAKER .... Pittsfield.
County Surveyor and Civil Engineer.

GEO. F. WIGHTMAN .... Peoria.
City Engineer.

JOEL P. WILLIAMS .... Momence.
Civil Engineer.

ROBERT WINNING .... Salem.
State Mine Inspector.

J. WITHINGTON .... Mattoon.
Surveyor.

J. O. WRIGHT .... LaFayette, Ind.
Civil Engineer.

HONORARY MEMBERS.

F. HODGMAN .... Climax, Mich.
EZRA D. SHREVE .... Bucyrus, Ohio.
FRED. J. SAGER .... Columbus, Ohio.

Attention is called to the notice of the Fifth Annual Meeting to be held in Peoria, in January, 1890, as given on page 149.

PROCEEDINGS

—OF THE—

FOURTH ANNUAL MEETING OF

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS,

—HELD AT—

BLOOMINGTON, ILLINOIS, JANUARY 23-25, 1889.

The meetings were held in the Council Chamber of the City Hall, Bloomington.

WEDNESDAY—AFTERNOON SESSION.

At 3 o'clock, p. m., President Elliott called the society to order and announced the beginning of the fourth annual meeting.

The Secretary and Treasurer, Prof. A. N. Talbot, reported the work of his office during the past year. The report was referred to the executive board.

The executive board approved the following named persons for membership, who on ballot received the vote of the society:

A. S. Aloe	St. Louis
S. N. Howard	Chicago
E. L. Morse	Cazenovia
Jacob A. Harmon	Milford
T. A. Allen	Mattoon
James F. Parr	New Burnside
C. H. Tryon	Greenwood
John H. Diers	Sibley
G. W. Gastman	Hudson
L. B. Neighbour	Dixon
E. I. Cantine	Bloomington
Geo. W. Richards	Carthage, N. M.
Emil Rudolph	Chicago
A. C. Schrader	Joliet
Daniel W. Maher	Chicago

George F. Samuel...Chicago
Ethan Philbrick...Western Springs
George Dixon...Alton
N. D Reed...Handy

The President asked the new members to rise as he read off their names, and he formally introduced them to the old members of the society.

Mr. Bell, chairman of the committee on Land and City Surveying, reported for the committee. Several questions asked by the committee were discussed by the society, orally, or with written articles.

The paper, Subdivision of Anomalous Sections, was read by Mr. Niles. Discussion.

The paper by Mr. Chamberlain, Engineer Sny Island Levee Drainage District, entitled Levee Construction, was, in the absence of the writer, read by Mr. Talbot. Discussion.

The President announced that the Executive Secretary had received the Manual of Land Surveying as a present to the society from the author, Mr. Hodgman, of Michigan.

On motion the book was placed in the custody of the Executive Secretary and he was instructed to convey to Mr. Hodgman the thanks of the society for the book, and an expression of its appreciation of the value to the profession of the work done by the authors. Adjourned.

EVENING SESSION.

President Elliott called the meeting to order at 7:30 o'clock, and introduced Hon. J. R. Mason, Mayor of the city of Bloomington, who delivered to the society an address of welcome. Mr. Mason congratulated the society on its number present, the interest manifest in the work of the engineer and invited an inspection of the engineer's work executed in his city during the past few years. His remarks were highly enjoyed by the members.

President Elliott responded to the address in a few fitting remarks.

The President delivered his annual address, taking for a topic, Natural Water-sheds and their Drainage Discharge.

Paper by Mr. Balcom on the Progress of the Cairo Bridge. Discussion.

Topic No. 4 was taken up and discussed,--To what extent do you use the needle in surveying? What, if any, do you consider the advantages of the compass over the transit? Discussion was opened by D. H. Davison and D. L. Braucher.

Topic No. 6, What is the proper thickness of cover-stones for box culverts for different spans and heights of embankments? was discussed, Prof. Baker leading.

Topic No. 5, What is the method and rate of paying for surveys in your city work? was discussed.

A letter from Mr. Armstrong, the county surveyor of DeKalb county, was presented, in which a question was raised in regard to a certain system of computing areas of land. On request, the question was answered by Professor Baker.

In the absence of Mr. Mead, Executive Secretary Talbot read the report of the committee on Municipal Engineering.

On motion a committee for the nomination of officers was appointed by the President, consisting of D. J. Stanford, H. C. Niles and A. H. Bell, with instructions to report at the time set for the election of officers.

Mr. Talbot read a communication from the Engineers' Club, of Kansas City, giving the plan of a bill which they were urging on the legislature of Missouri for the official inspection of bridges throughout the State, and asking our society to take similar action as to inspection of bridges in Illinois. The communication and bill were referred to the Legislative and Judiciary committee with instructions to report to the society during the meeting.

THURSDAY—MORNING SESSION.

The paper by Mr. Richards on "A New Mexico Coal Mine" was read by A. C. Braucher, in the absence of Mr. Richards.

Topic No. 11 was taken up. What changes do you suggest in the present Mining law? Discussion.

The paper by Mr. A. C. Braucher, "Mining Plant" was read and followed by a paper by Mr. Morse on Methods of Measuring and Computing Earth Work, and a paper by Mr. Bell, on Bloomington. Discussion.

Topic No. 7 was considered. What do you consider the best method of sewer ventilation? and followed by

Topic No. 3. Is it necessary to use double-strength culvert pipe for culverts, or will ordinary sewer pipe be strong enough? Discussion was opened by Mr. Baker.

Chairman Bell, of the Executive Board, reported that the Treasurer's books and vouchers had been examined by them and found correct, and further, the board declared an assessment for dues the

same as made last year—two dollars for new members and four dollars for old members.

Paper, A Plea for Brick Construction in Engineering, was read by Professor Baker. Discussion.

AFTERNOON SESSION.

After a visit to the extensive machine shops of the Chicago & Alton R. R., and to the city water works and electric light plant, and an examination of the brick pavements of the city, the society was called to order by President Elliott, at 4:45, p. m.

Chairman Hansel, of the Legislative and Judiciary committee, reported a bill to be advocated before the present General Assembly, for licensing surveyors and civil engineers. He also recommended that the law creating the board of Railroad and Warehouse Commissioners be amended so as to provide for four commissioners, and that at least one of them be a civil engineer.

On motion of Mr. Burnham that part of the report referring to the Railroad and Warehouse Commissioners was adopted.

Mr. Ela moved that the bill reported by the committee for licensing surveyors and civil engineers be approved by the Society and advocated before the legislature. After a long discussion a motion was made by Mr. Wightman to lay the whole matter on the table, and it prevailed.

The committee desired that the communication from the Kansas City Engineers' Club be referred to the new committee.

EVENING SESSION.

The Society met at 7 o'clock. At the request of the President, the engineering drawings and views on exhibition, of which there were over seventy, were explained by the members.

Paper by Mr. Balcom, Causes of Railroad Accidents, was read.

Topic No. 10, The advantages and disadvantages of the premium system for excellence in track work, was discussed by Mr. Hansel and Mr. Hill.

Topic No. 16, What is the cost of track laying, followed next.

A paper by Mr. Wightman on Pavements was read.

Mr. Greeley read a synopsis of his paper on The Metric System.

A paper on Specifications by Mr. W. D. Clark, was read.

FRIDAY—MORNING SESSION.

A paper by Mr. Lewis on Roads was read and discussed.

The programme was continued with a paper by Mr. Hill, a supplementary paper on Nichols' Hollow Culvert. Discussion.

The paper by Professor Talbot, Sewage Disposal, was read and on request of several members the paper of Mr. Bullard on the Source of the Water-supply of the City of Springfield, was read also, that both might be discussed at once. Discussion.

Mr. Enos' paper, By What Rules of Law are Course, Distance and Area governed in the Subdivision of Government Sections, was read by the Secretary. Discussion.

Topic No. 13 was announced. How far and under what circumstances will a corner or line ripen into title? Discussion.

On motion of Mr. Bullard the programme was continued without the noon recess.

A paper by Mr. Cantine, "A Park Topographical Survey," was read and discussed.

On motion Mr. Hodgman's paper was, without reading, referred to the Executive Board for publication.

On motion of Mr. Bell, a paper received by him from Mr. Alvord, as a part of the report of the committee on Municipal Engineering, was referred to the Executive Board.

Mr. Balcom moved that the paper of Mr. Healey be referred to the Executive Board for publication without reading, and the motion was carried. A similar motion prevailed referring the paper of Mr. Mead.

The paper by Mr. Garrett on Electric Lighting in Small Cities, was read by Mr. Talbot.

Topic No. 1 was announced and discussed by Mr. Bullard and Mr. Wright. What, based on your experience, is the best routine system of superintending work?

Topic No. 2. What theory in regard to the size of drainage pipes does your experience approve, was discussed.

Under the order of unfinished business the Secretary read the amendment to the Constitution proposed at the last convention, and on motion the amendment was adopted.

Following is the amendment:

ARTICLE IV.—Section 6. At each annual meeting the President shall also arrange, if possible, to secure the attendance of one member of the Society at each meeting of other State Societies, whose publications are given in exchange for the publications of this Society; it being stipulated that no expense shall be incurred in this business without the express sanction of the Executive Board, and in no case shall such expenditure be so authorized unless there be a surplus at the time in the treasury, above all existing claims.

It was decided by vote to hold the fifth annual meeting in the City of Peoria.

The executive Board reported favorably the following amendment to the Constitution:

ARTICLE IV.—Section 2, shall read, They shall be elected by ballot on the second day of each annual meeting, and their term of office shall begin at the close of said meeting.

Upon motion, the amendment was adopted by the society.

The special committee on nomination of officers reported names as follows:

President	C. G. Elliott. Gilman
Vice-president	D. W. Mead. Rockford
Executive Secretary and Treasurer	A. N. Talbot, Champaign
Recording Secretary	S. A. Bullard, Springfield
Executive Board	I. O. Baker, Champaign G. F. Wightman. Peoria Chas. Hansel, Springfield

And on separate ballots the candidates were elected as reported.

Mr. Hill introduced the following resolution, which was unanimously adopted:

Resolved, That the thanks of the Society are hereby extended to our local members for the entertainment provided us by them, and also to the various officers and residents of the City of Bloomington, for courtesies shown to us during the present session.

Remarks were made by President Elliott on assuming the duties of President for another year, after which he declared the fourth annual session adjourned without date.

S. A. BULLARD, *Recording Secretary.*

PRESIDENT'S ADDRESS.

NATURAL WATER-SHEDS AND THEIR DRAINAGE DISCHARGE.

BY C. G. ELLIOTT, OF GILMAN.

Members of the Illinois Society of Engineers and Surveyors:

For the fourth time we are assembled in annual meeting, under more favorable auspices than ever before. It is gratifying to all of us to note the increased membership of our society, and the growing interest which is yearly being manifested throughout the state in the profession which we represent. Our society doubled its membership during the first three years, and the outlook for continuing this ratio is, at present, very favorable.

We have reason to congratulate ourselves as members of the profession, as well as members of this society, upon a year of general prosperity which has passed, and upon the success of many undertakings in engineering. Our field is a broad one and is fast resolving itself into special departments, which, in turn, occupy the time and attention of individual practitioners. So broad is this general field, that any review of the progress made, such as would be of proper length for an address of this kind, would be meager and would also trespass upon the work of one or more of the committees. I shall, therefore, take up a special subject for discussion, and in so doing follow the example set by older societies and more illustrious men.

Before I do this, however, you will pardon me if I indulge in expressions of the pleasure which I feel in counting myself a member of this society, and of calling attention of new members, and of those who contemplate becoming members, to the advantages which are now offered to members of the profession, as compared with those which were offered a few years since.

Societies of this character, in which practical men meet to discuss practical questions, are of recent origin, and form a part of professional education of which no man who is alive to his interests can well afford to be deprived. To make the application of this more pointed, running the risk of being charged with egotism, I will draw from my own experience. Eleven years ago I came out of the class room with no practical experience, equipped only with knowledge which is imparted by the text-book and class practice. Engineering work rested under the shadow of the financial depression of 1873–4. No employment could be obtained on the U. S. Coast Survey, as the places were all filled by military cadets. I had never witnessed the running of even a sub-division line by a practical man, much less the construction of work which calls for a knowledge of practical affairs. No State Society Reports, such as can now be ob-

tained, were to be had. No older engineer or surveyor would be troubled with an inexperienced man at any price, and he was exceedingly careful about imparting any information which would be of any practical use. So keenly did I feel this treatment on the part of those already established in the profession, that I resolved that if ever I was fortunate enough to secure any professional experience, which at that time looked exceedingly doubtful, no young man coming to me in quest of information which is not given in the schools, would ever go away empty or without at least an encouraging word. I trust that in addition to the valuable information of which we are permitted to avail ourselves, the Society is fostering and encouraging a fraternal feeling, and is fast overcoming that antipathy which the older and more isolated surveyors were accustomed to have for one another. We know that this will be true when all members of the profession within the state become members of the society.

It is well for us to make ourselves acquainted with what has already been accomplished in any line of practice, before we begin work on our own account. We may flatter ourselves that we are original, when, in fact, we are merely traveling in the foot-prints of others without suspecting it. This is merely a hint, and that to the wise is sufficient. Napoleon said to his army when fighting in Egypt within plain view of the pyramids: "Soldiers, forty centuries look down upon you." So to-day with us, the engineering achievements of the past look down upon us and encourage us in every department of work. But leaving you to take up at your leisure a more extended view of the field, I ask the privilege of directing your attention to the subject of

NATURAL WATER-SHEDS AND THEIR DRAINAGE DISCHARGE.

No apology is now needed for bringing before a society of this character matters pertaining to land drainage. Previous to the last ten years so little attention was given to this department of internal improvement, that in this country it is comparatively new. The demand for transportation facilities of various kinds has been so great, in order that the natural resources of our rich and rapidly growing country might be appropriated, that the development of unimproved lands by the use of capital, directed by engineering skill, lags behind. During recent years our people have seen that such improvements should keep pace with municipal and transportation projects, or these projects would suffer.

It may be remarked that in Europe the promotion of improvements in the line of drainage, irrigation and embanking, has been a necessity in order that food might be provided for her increasing population, while in turn this increase of population has been necessary to the support of the transportation facilities, the mills and factories which have been put into operation. This subject has there engaged the thought and effort of the best engineers. Even governments have taken up the matter as a subject of national importance. The extensive irrigation canals of southern Europe, the immense

tracts of productive lands which have been made so by drainage and embanking, and which may be found in almost every part of that highly improved country, attest the truth of this, and afford to us in this country a precedent for similar work which may be adapted to our needs.

The industries of any prosperous country are always very closely interwoven. It is also true that the interests of engineers who are engaged in the development of these industries are closely related and dependent one upon the other. It follows that we are mutually interested in the uniform and steady advancement of each one of our specialties, and should add whatever we may to the fund of information on any line of practice.

The discussion of natural water-sheds as to their physical characteristics, laws of their drainage and the canals required for such purposes, is a matter which, considering the present interests in such subjects, may profitably engage our attention.

Water-sheds may be studied with two different purposes in view. We may wish to know how large a per cent. of the rainfall may be obtained and made available for a water supply, taking into account a certain reservoir storage; or we may desire to find the per cent. of rainfall which it will be necessary to remove, and the means for effecting such removal in order to give efficient drainage for the area for the purposes of profitable cultivation.

For the purposes of drainage we may classify as follows:

First. As to slope of surface; whether slopes are steep, moderate, or nearly level. Light slope, one to four feet per mile. Moderate slope, four to eight feet per mile, steep slope over eight feet per mile.

Second. As to surface soil, and subsoil. The surface soil may be open and porous, or it may be compact and tenacious. Subsoil may be gravelly or sandy, thus permitting water to flow in sub-currents. It may be open joint clay, which will give considerable storage capacity, or it may be hard-pan clay, but little pervious to the entrance of water.

Third. As to the kind and quantity of vegetation which will be produced when the land is reclaimed. Whether used for field crops, meadow and pasture, or for garden and high cultivation.

All of the above named conditions will affect the per cent. of rainfall which will be retained and appropriated by the land and by what grows upon it.

For the purpose of showing the effect of slope, I quote from Fanning* the following, which represents the ratio of annual rainfall to the mean annual flow of streams :

For mountain slopes and rocky hills	80 to 90 per cent
For wooded swamp lands	60 to 80 "
For undulating pasture	50 to 70 "
For flat, cultivated lands	45 to 60 "

*Fanning's Water Supply, page 77.

This is regarded as only approximate, and is the mean annual ratio. It is useful for our purpose only so far as it indicates in some degree the effect which the contour of the surface has upon the discharge from a water-shed.

The effect which the soil and subsoil have upon the absorption and retention of the rainfall is very marked. In some cases in which the soil is porous, or well drained, only ten per cent. is discharged from the basin; in others, only ten per cent. appears to be retained by the soil. An inspection of the ground, with a knowledge of the conduct of various kinds of soil and subsoil, or better yet, some experimental observations, will help to determine what effect to provide for in the several cases.

The effect which vegetation has upon the per cent. of flow in a given time is worthy of note. When the tract is covered with long grass, water finds its way to the outlet course much more slowly than when the ground is nearly bare or covered with short grass. This difference of time has been observed on tracts of considerable size, 2,000 acres to 8,000 acres, to be twenty-four hours. That is, the flood reaches its hight for the same tract twenty-four hours later when it is covered with long, thick vegetation, than when it is comparatively bare or covered with short vegetation, as in the case of pastured lands and mowed meadows. These conditions are changed during the same seasons by reason of the presence or absence of the modifying causes.

Is the discharge from various sections of a water-shed directly proportional to the corresponding areas?

Another factor which should enter into this discussion is this: Is the required capacity of any receiving drain of a water-shed directly proportional in various sections to the area from which it receives its drainage? That is, if a drain has a certain capacity midway between source and outlet, and which at that point receives drainage from one-half of the area, should it have twice that capacity at the outlet at which point all drainage of the tract passes? Let us examine the water-sheds of some large areas for light upon this point. The Mississippi river and its tributaries have been the subject of very many investigations, and to bring out data bearing upon this subject, I quote from Hewson the following table, which shows the sectional area of the Mississippi and its main tributaries from Cairo to the Gulf:

At Cairo the sectional area of the Mississippi is about	325,000	sq ft
Of the Ohio, at the junction, the sectional area is about	260,000	"
Of the St. Francis, at the junction, the sectional area is about	21,000	"
Of the White river, at the junction, the sectional area is about	28,000	"
Of the Arkansas river, at the junction, the sectional area is about	56,000	"
Of the Yazoo river, at the junction, the sectional area is about	21,000	"
Of the Big Black river, at the junction, the sectional area is about	21,000	"
Of the Red river, at the junction, the sectional area is about	52,000	"
Other tributaries	18,000	"
Total	802,000	sq ft
Of the Mississippi at New Orleans	480,000	"

From this it appears the sectional area of the river is only 155,000 feet greater at New Orleans than it is at Cairo, but that between these two points there have been accessions aggregating 477,000 feet, or a loss of 322,000 feet of the accessions, nearly equivalent to another river like the Mississippi at Cairo.

Another fact of the same kind is that the flood mark at New Orleans is twelve feet above low water mark, while at Cairo it is fifty feet above low water.

It is remarked that the Mississippi has a more narrow channel after it receives the Ohio than before, and further, that this is true after each accession below this. At Cairo the river is said to be one mile wide, and at New Orleans one-half mile in width. While this is true of the width, it is observed that the channel is deeper as it grows narrower, the truth of which is popularly established by the fact that the higher upstream a steamboat goes the more difficult navigation becomes.

The eminent hydraulician, Eytelwein, asserts that one river may absorb another of equal magnitude with itself, without producing a sensible elevation of its surface. Cressy sustains this by citing several instances of European rivers, among them the Inn, absorbed by the Danube, the Main by the Rhine, the Teverone by the Tiber. "This," he says, "takes place without making the receiving channel either deeper or wider, the only effect noted being an increase of velocity in the main channel."

Guglielmini sustains the conclusion by citing the River Po as having no larger channel after the accession of the Ferrara and Panaro than it had before.

Hewson accuses these eminent men of either being mistaken as to facts, or having stated them erroneously. While he admits that no additional width of channel or elevation of water surface takes place, there must be a deepening of the channel, as any probable increase of velocity will not account for the seeming paradox.

The Basin of the Great Lakes.—From Crosman's chart, which he has compiled from data, taken by the U. S. Coast Survey, I select the following matter, which bears upon our subject:

Average discharge of Lake Superior at St. Mary's river	86,000 cu ft per sec
Lakes Michigan and Huron at St. Clair river	225,000 " "
Lake Erie at Niagara	265,000 " "
Lake Ontario at St. Lawrence river	300,000 " "

	AREA OF WATER SHED.	AREA OF WATER-SHED AND WATER SURFACE.
Lake Superior	51,600 sq miles	82,800 sq miles
Lake Huron	31,700 "	55,500 "
Lake Michigan	37,700 "	60,150 "
Lake Erie	22,700 "	32,660 "
Lake Ontario	21,600 "	28,840 "

The discharge in cubic feet per second per square mile for the several basins is as follows:

Lake Superior basin	1.03 cu. feet
Lakes Superior, Michigan and Huron basin	1.13 "
Lakes Superior, Michigan, Huron and Erie basin	1.15 "
Lakes Superior, Michigan, Huron, Erie, and Ontario basin	1.15 "

From this it appears that the discharge from the several basins is nearly directly proportional to the area. It must be remembered in this case, that nearly one-third of the area of the basins given above is water surface, and cannot be regarded as conforming to the same laws as basins which are made up entirely of land surface. The lakes are large reservoirs, which are known to rise and fall with the quantity of rain which is precipitated. In this way they act to maintain a uniform flow of discharge, irrespective of the varying modifying influences which belong to the land surface.

The average discharge per square mile for the lake basin, as will be observed, is 1.1 cubic feet per second, with annual rainfall of thirty-one inches.

According to Stevenson, who cites Elet as authority, the Mississippi water-shed discharges per square mile only .54 cubic feet per second, with annual rainfall of over forty inches.

In the first case the discharge amounts to .04 inches per acre of water-shed in twenty-four hours, and in the second case only .02 inches, or about twenty per cent. of the annual rainfall is discharged.

One bearing of these facts upon the subject under discussion, is the great difference in the per cent. of discharge of two drainage basins of different character, and another is the small per cent. of discharge which finally takes place from a large water-shed.

SMALLER WATER SHEDS.

The question is, how far do the facts thus far presented affect conclusions regarding smaller water-sheds, as, for instance, those of from 2,000 acres to 40,000 acres? From observations and experiments made at various times, I have reason to believe that the same general laws hold good for all drainage areas, carefully taking into consideration the modifying conditions already mentioned. The manner of taking these into the calculations I will merely outline, drawing from my own practice.

Find the area of the water-shed and the surface slope in the line of the main drainage.

Divide the area into its tributary water-sheds, and note the slopes and kind of soil and other physical conditions in each. If detail drainage is to be taken up divide these into other tributary areas, in all cases noting acreage.

Beginning at the outlet, having rate of available fall and acreage, and supposing in this case that the land is of light slope and to be used for agricultural purposes.

Compute the size of the outlet ditch to carry ¼ inch depth per acre in twenty-four hours when filled within 24 inches of the surface of the land through which the ditch passes. Do not decrease this capacity up stream in proportion to acreage, but give it such size near the source that it will carry ¾ inch depth per acre, and proportion at intermediate points according to accessions received.

The tributary areas may be handled in the same way, considering at all times that the smaller the area the greater the per cent. of water we must expect to carry. We may regard $\frac{1}{2}$ inch as the mean for fields, to be increased or decreased according to laterals, slopes and kind of soil. I have found that in designing mains for tile drainage, the same general laws should be regarded, and are more often followed in practice than we are aware of.

The discussion of a question of this kind in this way may seem unprofessional and the conclusions indefinite. The matter, however, resolves itself into this: The drainage of each water-shed is a problem of itself, to be solved by itself upon general principles, but with data which can be derived only from the area to be worked upon, and further, that the success of its solution will depend largely upon the skill, knowledge and thoroughness of the designing and constructing engineer. There is an uncertainty about the work which cannot be overcome except by a thorough investigation of all of these points. When this is done each case can be formulated in a professional and satisfactory manner, and the works can be constructed with a fair degree of certainty of accomplishing just what it desired.

A PLEA FOR BRICK MASONRY IN ENGINEERING.

By Prof. IRA O. BAKER, of Champaign.

There seems to be a general opinion that brick masonry is in every way inferior to stone masonry. This belief may have been well founded when brick was made wholly by hand by inexpert operatives, and imperfectly burned by the old-time kilns, the product being then generally poor; but things have changed, particularly in Illinois, and the writer believes that the members of this society should recognize this fact and govern themselves accordingly.

Strength of brick—The writer has recently completed† an extensive series of tests on brick made by the soft-mud, the stiff-mud and the dry process, and finds that brick from four places in Illinois give results higher for transverse and compressive strengths and lower for the absorbing power than any he can find recorded. In a general way results show that the strength of what is known in this locality as paving brick are stronger than any stone in anything like general use in this state; in fact, the writer found that representative paving brick from three towns in Illinois stood more than any stone tested, although the latter included some of the principal ones of the Mississippi Val-

†Masonry Construction, Wiley & Sons, 15 Astor Place, N. Y. City.

ley. This only confirms the belief that brick which will stand the service in pavements, as successfully as they have done in numerous places all over the country, are sufficiently strong and durable for use in any masonry structure.

There are many engineering structures in which brick could be profitably employed instead of stone, as for example, the walls of box culverts, cattle-guards, etc., and the less important bridge piers and abutments, particularly of highway bridges. The correct rule for such structures is to construct them of as large stones as possible; but if they are built of good brick, laid in strong cement mortar, they will be more nearly monolithic and better than they generally are when constructed of stone.

Compressive strength of brick masonry.—Possibly there may be some one who is fearful that brick masonry will not stand the heavy pressures that may come upon it in engineering structures. To show that this fear is without any shadow of a foundation, I present tables I. and II.

TABLE I.

Absolute strength of brick masonry, and also its strength compared with that of the brick and of the mortar as determined by experiment, at the Watertown Arsenal with the U. S. testing machine, upon piers 12 inches square and from 1 ft. 4 in. to 10 ft. high.

Reference No.	Composition of Mortar.	No. of trials	Ultimate strength of pier in pounds per square inch.	Strength of the mortar tested in 6-inch cubes between steel, in pounds per sq. in. mean of 3 trials.	Strength of pier per sq. inch in per cent. of the strength per sq. inch of the brick. Min.	Max.	Mean	Strength of the pier in terms of the strength of the mortar, each per square inch.
1	1 lime, 3 sand	15	1,508	124	6	18	10	12
2	2 mortar, (1 lime, 3 sand), 1 Rosendale cement	1	1,646	183	....	....	11	9
3	2 mortar, (1 lime, 3 sand), 1 Portland cement	1	1,411	192	....	....	9	7
4	1 Rosendale cement, 2 sand	1	1,972	162	....	....	13	12
5	1 Portland cement, 2 sand	8	2,544	545	10	27	17	4.7
6	Clear Rosendale	...	....	521	....	....	...	....
7	Clear Portland cement	1	2,375	3,483	....	....	16	0.7

The brick in the above experiments had an average crushing strength of nearly 15,000 pounds per square inch when tested flatwise

between steel. The mortar was 14½ months old when it was tested, and the piers were from a year-and-a-half to two years old when they were tested. The piers were built by a common mason with only ordinary care. Their strength varied with the height; and, in a general way, the experiments show that the strength of a prison 10 feet high laid in either lime or cement mortar is about two-thirds that of a 1-foot cube. Hence, these experiments may be taken to fairly represent the strength of actual engineering structures.

TABLE II.

RELATIVE STRENGTH OF BRICK AND BRICK MASONRY LAID IN PORTLAND CEMENT MORTAR, FROM EXPERIMENTS MADE IN BERLIN—THE CONDITIONS BEING THOSE OF ORDINARY PRACTICE IN THAT CITY.

DESCRIPTION OF BRICK.	Average crushing strength of brick alone, in pounds per square inch.	Ultimate strength in lbs. per sq. in. of brick-work with mortar composed of			
		1 Lime. 2 Sand.	7 Lime. 1 Cement. 16 Sand.	1 Cement. 6 Sand	1 Cement 3 Sand.
Ordinary Stocks........................	2930	1290	1390	1610	1850
Selected Stocks........................	3669	1620	1760	2020	2320
Clinkers..................................	5390	2370	3590	2960	3410
Porous Bricks	2617	1150	1250	1440	1650
Porous perforated bricks..........	1105	530	570	650	750
Perforated bricks.....................	2759	1210	1320	1520	1710
Average efficiency of the masonry in per cent. of the strength of the bricks........................		44	48	55	63

Both of the preceding series of experiments show conclusively that the strength of brick masonry is mainly dependent upon the strength of the mortar. An increase of 50 per cent. in the strength of the brick shows no appreciable effect on the strength of the masonry. Notice, however, that the masonry in the fifth line of Table I., is 70 per cent. stronger than that in the first, due to the difference between a good Portland cement mortar and the ordinary lime mortar. In Table II. notice that brick laid in a 1 to 3 Portland cement mortar is nearly 50 per cent. stronger than in a 1 to 2 lime mortar. Similar experiments show that masonry laid in mortar composed of one part Rosendale cement and two parts sand, is 56 per cent. stronger than when laid in mortar composed of one part lime and four parts sand. A member of the Institute of Civil Engineers (London) says that brick-work laid in lime is only one-fourth as strong as when laid in clear Portland cement. Probably the difference in durability between cement mortar and lime mortar is considerably greater than their difference in strength.

PRESSURE ALLOWED IN PRACTICE.—The pressure at the base of a brick shot-tower in Baltimore, 246 feet high, is estimated at $6\frac{1}{2}$ tons per sq. ft. (about 90 pounds per sq. inch). The pressure at the base of a brick chimney at Glasgow, Scotland, 468 feet high, is estimated at 9 tons per sq. ft. (about 150 pounds per sq. inch); and in heavy gales this is increased to 15 tons per sq. ft. (210 pounds per sq. inch) on the leeward side. The leading Chicago architects allow 10 tons per sq. ft. (140 pounds per sq. inch) on the best brick-work laid in 1 to 2 Portland cement mortar; 8 tons for good brick-work in 1 to 2 Rosendale cement mortar; and 5 tons for ordinary brick-work in lime mortar. Ordinary brick piers have been known to bear 40 tons per sq. ft. (560 pounds per sq. inch) for several days without any sign of failure.

The preceding tables appear to show that present practice is very conservative with regard to the pressure allowed on brick masonry. According to Table I., the ultimate strength of the best brick laid in ordinary lime mortar is 110 tons per sq. ft., if laid in 1 to 2 Portland cement mortar, 180 tons; and, by Table I. the strength of ordinary brick in 1 to 2 lime mortar is 100 tons per sq. ft., and in 1 to 3 Portland cement mortar, 140 tons. From the above, it would seem that reasonably good brick laid in good lime mortar should be safe under a pressure of 20 tons per sq. ft., and that the best brick in good Portland cement mortar should be safe under 30 tons per sq. ft.

The heaviest pressure borne by any masonry structure—the towers of the Brooklyn bridge—is a little less than 400 pounds per sq. inch (28 tons per sq. ft.); while Table I shows that the average strength of brick piers laid with mortar composed of one part Rosendale cement and two parts sand, is 1,972 pounds per sq. inch (140 tons per sq. ft.), and with a mortar composed of one part Portland cement and two parts sand is 2,544 pounds per square inch (180 tons per per sq. ft). If brick masonry of the quality of last mentioned piers were substituted for the granite masonry of the towers of the Brooklyn bridge, the factor of safety would still be about $6\frac{1}{4}$; and if substituted for the limestone masonry, the factor would be 20.

STONE VS. BRICK MASONRY.—Brick masonry is superior to stone masonry in several particulars, as follows: 1. In many localities brick is cheaper than stone, since the former can be made near by, while the latter must be shipped. 2. As brick can be laid by less skillful masons than stone, it costs less to lay it. 3. Brick is more easily handled than stone, and can be laid without any hoisting apparatus. 4. Brick requires less fitting at corners and openings. 5. Brick masonry is less liable to great weakness through inaccurate dressing or bedding. 6. Brick-work resists fire better than limestone, granite or marble; sandstone is the only variety of stone that can compare with brick in power to resist fire. 7. Good brick stands the effect of weathering and of the acids in the atmosphere better than standstones, and in durability even approaches some of the harder stones. 8. All masonry fails when the mortar in its joints disintegrates or becomes dislodged; therefore, brick masonry will en-

dure the vicissitudes of the weather as well as stone masonry, or even better, since the former usually has thinner joints.

Stone masonry is preferable to brick masonry when the strength demanded (or rather the degree of security required), or the effect required, warrants the expense necessary to lay large blocks having well-dressed faces and consequently thin joints. Stone masonry is also to be preferred in any locality where the conditions of the market are such that the total cost of the stone masonry is less than that of brick masonry of equal strength and durability. Stone fronts have almost ceased to be built in Chicago, where they were once so common. . Brick masonry is now employed mainly because it is more durable. In this connection it should be borne in mind that durability is generally the more important element; and that durability depends mainly upon the thickness of the joints and the quality of the mortar. The latter is the one neglected element in nearly all masonry, and particularly with brick.

Requisites for good brick.—1. A good brick should have plain faces, parallel sides, and sharp edges and angles. 2. It should be of fine, compact, uniform texture; should be quite hard; and should give a clear ringing sound when struck a sharp blow. 3. It should not absorb more than one-tenth of its weight of water, and first-class brick not more than one-twentieth. 4. The specific gravity should be 2 or more. 5. The crushing strength of half-brick, when ground flat and pressed between thick metal plates, should be at least 7,000 pounds, and first-class at least 10,000 per square inch. 6, The modulus of rupture should be at least 1,000 pounds per square inch.

The present length of this paper is such as to make it unwise to expand these items further.

DISCUSSION.

Mr. Rottman.—I know of work in Germany bearing 240 pounds to the square inch. In walls of brick and terra cotta, very old, the stone and marble are gone from decay, but the clay work is all there in good condition. I believe for future work that brick is coming to the front.

Mr. Baker.—There is no danger of even soft brick being crushed by any load that will be brought upon it in ordinary construction, public opinion to the contrary notwithstanding. For example, I recently tested some of the softest brick I could find, and found that they stood a pressure equal to a column of such brick 960 feet high. The masonry in the first line of Table I. stood a pressure equivalent to a column of such masonry 2,250 feet high; and the weakest masonry in Table II. stood a pressure equivalent to a column of ordinary masonry 795 feet high. For inside walls and various other places,

soft brick are amply sufficient. P. S.—I have no financial interest in brick.

Mr. Sizer.—Professor Baker says soft brick are useful for many things. How do they stand frost?

Mr. Baker.—Frost is the most severe test brick is called upon to endure, and in this respect soft brick are very poor.

Mr. Clark, of Springfield.—The great source of failure is more in the manner of construction than in the material.

Mr. Balcom.—The paving brick is subject to different influences from those in walls. Is the wear in paving brick correspondent with the hardness? In some crossings in Champaign are eye brick. Will ordinary hard brick stand all that is required in a pavement?

Mr. Baker.—The eye brick absorb but little water and are less subject to the action of frost. I have carefully examined a number of crossings laid in "arch" brick, and I find the brick standing the wear remarkably well. In closing I would remind you that it is not the strength or hardness of the brick which should receive the most attention, but instead the absorptive power, which measures its durability. This feature of the subject is well worth more than a passing notice.

Municipal Engineering—No. 2.*.
Lake View.

By JOHN W. ALVORD, † of Chicago.

The city of Lake View lies bordering on Lake Michigan and adjoining the city of Chicago on the north. It covers an area of 10½ square miles and practically forms a part of Chicago, being the second largest residential suburb both in population and wealth.

The most interesting fact in connection with Lake View has been its remarkable growth. In 1880 the population was 6,600; in 1884 it had increased to 20,000; and the best present estimates place it at, or near, 50,000 inhabitants. During this period about $1,500,000 was expended on public improvements. A city government was organized, water-works built and their capacity twice doubled.

*Given as an appendix to the report of the committee on Municipal Engineering. No. 1, on Rockford, was published in the third annual report.

†Late City Engineer of Lake View.

A drainage system involving over sixty miles of sewers was planned and carried out, some fifteen miles of streets were paved and lighted, and various other improvements of lesser importance were pushed forward on a similar scale.

Under these circumstances the manner of providing for the municipal improvements seems of general interest, and I purpose as far as I am able in the limits of a paper of this kind to show how some of the problems were met.

DRAINAGE.

The topographical features of Lake View are simple and consist of three well defined water-sheds. A long narrow strip of low-lying bog and wooded sand ridge along the lake shore; an abrupt rise to the dividing ridge parallel with and about one-half mile distant from the lake; from this westward a prairie sloping with a gentle inclination of about four to six feet per mile to the north branch of the Chicago River, which lies for the most part just outside of the corporate limits; these with a third water-shed in the northern and undeveloped end of the city formed the salient features of this district.

The combined system of sewerage was early decided upon under John A. Cole, C. E., of Chicago. Generally speaking the formula used by the writer was that of Sir Joseph Bazalgette.

$$Log\ A = \frac{10\ Log\ d - Log\ Z - 6.8}{3},$$

modified so as to drain one-half more area.

This provides smaller sewers than are used by the city of Chicago, but was thought to be warranted for the following reasons. 1st. The ground in Lake View is level, sandy and porous and acts as a great reservoir absorbing a large percentage of the rainfall, most of which ultimately finds its way into the brick mains by percolation and is gradually removed. 2nd. Lake View is largely a residential city and has a less area of roof and pavement and a large per cent. of lawn and parking space.

Experience has shown, so far, that this modification is a correct one, and the most severe storm known in twelve years, which occurred in 1886, failed to entirely fill the sewers except in one instance.

Tne falls obtained in Lake View are such as to provide a uniform velocity of 2½ feet per second and the average depths maintained are 10 feet in business localities and 8 feet in residential districts.

Man-holes are provided at every change of grade or alignment and generally at distances of one hundred feet apart, except on large brick sewers, where they are from 165 feet to 330 feet apart.

Ventilation is effected by perforated iron man-hole covers, and the house drain is also ventilated at the curb. The writer is strongly of the conviction that numerous man-holes both for inspection and ventilation are a necessity in any well-designed sewer system.

One of the largest problems presented in the drainage of Lake

View arose in founding a proper outlet for a large portion of the western water-shed. The north branch of the Chicago River lies in greater part just without the city's western boundary. In one portion, however, where it passes through the south-west corner of the city it is dredged and docked and its level does not rise much above that of Lake Michigan. North of this, however, it reduces to an insignificant stream, dry in summer and liable to floods in late winter and spring—altogether a very unsuitable outlet for sewerage. It became necessary for this and other reasons to lay what might properly be called a large intercepting sewer nearly three miles long and having its outfall in the docked portion of the river. This important work was completed in spite of much opposition, and drains altogether 1,450 acres, the largest drainage district of the city.

Another most interesting drainage problem was found in connection with the low bog lands lying adjacent to the lake shore. Storms on the lake had the tendency to choke up the mouths of the few sewers that were early built so that constant attention was needed to keep them open. But the greater evil of the matter was the impression which gained ground, even among engineers, that the mouths of these sewers must not be placed too low, thus involving an expensive raise of grade over the whole district. This difficulty was met by devising an iron pipe outlet with a reduced diameter which extended into deep water and was supported by piles. The end of this pipe was turned downward with an elbow and its bottom coincided with the bottom of the main sewer. Its proper diameter was calculated from the size of the sewer and its capacity under a head made equal to the flow by gravity in the main sewer when running nearly full. It was found in practice, that during the heaviest storms, the outward flow of the sewer was uninterrupted, and its surface was even with the average lake level. This fact allowed the mouths of sewers to be put much lower, avoiding the large outlay which would have resulted from a general raise of grade.

The final disposal of Lake View sewage presents difficulties similar to the Chicago drainage problem and properly should be considered with that problem.

WATER SUPPLY.

Water-works were originally built in 1876 under the supervision of John A. Cole, C. E. Their capacity was 5,000,000 daily and they were on the direct pressure system without stand-pipe or reservoir. The supply was taken from Lake Michigan at a point 1,700 feet from the shore and five miles north of the Chicago river through a submerged wrought iron crib at the bottom of the lake. A wrought iron pipe of sixteen inches diameter with flexible joints at intervals laid on the bed of the lake conveys the water to the shore. Two geared pumps with condensing engines drew water directly from this pipe and forced it into the street mains, maintaining a constant pressure of about fifty pounds to the square inch.

In the course of time the rapid growth of Lake View compelled various extensions of the works, so that the original plant now forms but a small part of their capacity. In 1888, owing to neglect on the part of the authorities to earlier provide for extensions, large additions had to be made to the works while running at full speed.

The present plant consists of two inlet pipes 20 and 16 inches in diameter and extending 2,000 and 1,700 feet into the lake respectively; also of two shore or emergency pipes of 20 inches in diameter terminating in the breakwater about 300 feet from the works. These inlets lead into two wells 12 and 16 feet in diameter and about 20 feet deep, so arranged that one may be cleaned while the other is in use. From these suction pipes lead to the pumps, three in number —one Holly engine of 12,000,000 gallons capacity; one Worthington direct-acting duplex pump of 5,000,000 gallons capacity; and one of the original geared pumps of 3,000,000 gallons capacity.

There is no stand-pipe or air chamber for controlling the pressure in the mains and the want of such plant has never been felt. The writer is of the opinion that a large amount of capital has been invested throughout the west in such plants from which no return has been received adequate to the outlay incurred.

The present distribution system of the Lake View water-works consists of about seventy miles of water mains from 4 inches in diameter up to 24 inches. In fixing the minimum size of street mains at 4 inches in diameter, in his early connection with the corporation, the writer considers that he fell into an error common to those having charge of water-works in growing towns. Six inches in diameter is the least size that should be laid for street mains, even in new works where consumption is small. A six inch pipe costs but one quarter more than a four inch pipe and has nearly double its capacity.

Troubles with the inlet pipes have been, briefly, breaks in the pipe occasioned by changes in the bed of the lake, accumulation of sand in the pipe, and anchor ice at the crib in certain conditions of the weather in winter. The best method of meeting the difficulty of anchor ice is, perhaps, an ample area of intake pipe and a much multiplied screen surface at the crib.

PAVEMENTS.

Macadam is the favored pavement in Lake View. The standard roadway is 12 inches deep in the center and 9 inches deep on the sides when finished. A central section of this roadway consists of 6 inches of broken limestone, $2\frac{1}{2}$ inch ring, covered with 4 inches of the same material, $1\frac{1}{2}$ inch ring; then a layer of one inch of fine screened gravel, covered with a layer of one inch of crushed granite.

This forms a most excellent roadway for light travel. Business streets are generally paved with cedar block, under Chicago specifications.

SPECIAL ASSESSMENTS.

All the improvements in Lake View, with the exception of the water-works, are made by special assessment upon the property benefited. A special bureau, with complete records of property owners and previous assessments, is provided.

In street paving the city pays the cost of the intersections, and the balance is assessed upon the abutting property per front foot, allowance being made for corner lots.

In water mains, the cost of a 6-inch main is assessed upon the property, and the balance or difference between the cost of 6-inch and the size actually used is assessed upon the city. Six-inch is now the minimum size laid.

In sewers the following system is pursued: The city is divided into districts, each of which is drained by a main sewer, and the estimated cost of this main sewer is assessed only upon the district benefited, except that the city at large pays a general benefit equal to the amount of its intersections abutting the main, and reckoned on the basis of the amount paid by the private owner directly fronting the main. Property fronting directly on the main is assessed per front foot an amount found by experience equal to the cost of completed sewerage in a district. The balance, which is called the indirect benefit, is spread per front foot over the district in two ways:

1st. Equally, if the plan of drainage of that district shows that laterals drain directly into the main.

2nd Unequally, if it is found that, owing to the shape of the district, submains must be built before the lateral can be laid, allowance being made for a future assessment on that subdistrict in which the submain is to be built.

RECORDS.

The Records of the Engineer Department of Lake View are as follows:

1st. The City Atlas on a scale of 100 feet to one inch.

2nd. The House Number Map on a scale of 100 feet to one inch, numbering every 20 feet of lot frontage.

3rd. The Water Pipe Map on a scale of 200 feet to one inch (with no lot lines), showing the location and size of all street mains, the location of valves, hydrants and special castings, and the size of all unused tees or crosses.

4th. The Sewer Map (similar to the above), showing the location and size of all sewers, man-holes, catch basins, and size of unused street junctions.

5th, The Sewer Profile Books, which show the elevation of the natural surface, the depth and grade of the sewer and the established grade of the street. The standard scales adopted for sewer profiles are five feet to one inch vertically, and 200 feet to one inch horizontally.

6th. The Record of Private Drains and Water Service connections, drawn to a scale of 50 feet to one inch, and showing the

location and size of all the private drains as reported by the City Drain Inspector; also the location of unused drain stubs in the main sewer; also the location of every tap, stop box, and private water pipe as reported by the city tapper.

7th. A map of the city on a scale of 400 feet to one inch, showing the location, length, material and condition of all sidewalks as reported by the district overseers of highways.

8th. A map of the city on the same scale as above, showing the location of every street lamp, gas post and line of gas pipe as reported by the Gas Company.

In addition to the above are the index and file of plans for special improvements, the indexed field books on file, the files of special assessment plans which are furnished the assessment bureau from the engineer's office.

With this brief account of some of the salient features of municipal engineering in Lake View, the writer closes in the hope that his experience will not be without interest to the members of the society of this great state, the future of whose municipalities affords so vast a field for their activities.

MUNICIPAL ENGINEERING—No. 3.* BLOOMINGTON.

By A. H. BELL, of Bloomington.

Bloomington, the county seat of McLean county, is situated in the central part of Illinois, in latitude 40° 30′ north, and longitude 12° west from Washington.

The city was incorporated Feb. 19, 1850. The corporate limits are two miles square. The government administration is under special charter. The mayor and twelve aldermen are elected, while the other officers are appointed by the council. The present population is 25,000. Topography of the country: prairie, slightly rolling. Soil: from two to four feet, black loam, underlaid with yellow and blue clay; no rock; occasional veins of sand and gravel.

Fiscal year begins May 1st, terminates April 30th.

CITY ENGINEER'S OFFICE.

The City Engineer is appointed by the council each year. Bond, $5,000. Salary, $1,200. He acts all the year.

One Assistant Engineer is appointed by the council. Salary, $660. Bond, $1,000. Other help is allowed as necessity requires.

*Given as an appendix to the report of the committee on municipal engineering.

In all large and important public improvements an inspector is appointed to act under the city engineer and to stay upon the work all the time.

The duties of the city engineer are briefly given in Section 1, Article 7, Revised Ordinances of the city, as follows:

"It shall be the duty of the city engineer to make the requisite maps, plans, specifications and estimates for all work constructed by the city or under its authority.

To keep a systematic record on the books of the city of all transactions within his department, to carefully preserve in his office all maps, plans and surveys of the city, and all records, books, papers and writings made by him, or coming to or being in his hands as such city engineer.

To keep in a suitable book, to be provided by the city, all grades established by the city council. Said grade book shall be kept in the office of said engineer and shall be the exclusive property of the city, and all entries therein shall be made in ink, and shall contain a record of all bench-marks established in the city.

To give grades of streets or alleys to persons desiring to build or construct sidewalks and street lines, to persons desiring to construct curbing, when instructed to do so by the city council or its authorized committee; Provided, that no grade shall be given unless the same is established by ordinance.

He shall supervise the construction of all street pavements, sewers and drains, and shall make all surveys within and for said city that he may be called upon to make, and shall employ necessary chainmen and such other assistants as the city council may authorize, and said chainmen and other assistants shall, before entering upon their duties, be sworn by the mayor to measure accurately and justly and to perform their respective duties to the best of their knowedge and ability.

The city engineer shall be ex-officio commissioner of sidewalks and special assessments, and as such shall keep a full record of all special assessments. He shall prepare all descriptions of property assessed, with owners' names, and all notices required to be given where property has been purchased by or on behalf of the city for unpaid special assessments, and perform such other duties in relation to sidewalks and special assessments as the council may from time to time direct."

SEWERS.

Bloomington has what is known as the combined system of sewerage. The land is sufficiently rolling to afford abundance of fall for sewerage purposes. Two large brick sewers (6 and 8 feet in diameter), one in the north part of the town and one south, uniting in the western part of the city, constitute the main sewers. We build no brick sewers smaller than two feet in diameter, and none of sewer pipe larger than 18 inches in diameter.

Specifications for pipe are given in Exhibit C.

PAVEMENTS.

We have experimented with many of the various forms of pavements, and still have samples of brick, macadam and block stone from which to draw conclusions. All the conclusions necessary were attained some time back, however, as brick is now the only material talked of.

We get very superior brick here, and the results obtained from their use are highly satisfactory. We are laying more or less every year, with a prospect of putting down about three miles the coming season. The brick pavement on the west side of the square was laid about 16 years ago; it is quite good now, as you may see from inspection, although it has had but slight repairs. The brick pavement on the south side of the square was laid about nine years ago and is yet very complete; it has had no repairs that I am aware of. The specifications for these pavements are given in Exhibit A. Our brick pavements cost about $1.65 per square yard laid, exclusive of stone curbing.

All our brick pavements now laid are supplied with stone curbing 24″×4″—no pieces less than three feet long. Our curbing has cost us all the way from 58 to 66½ cents per lineal foot, set. Specifications are attached marked Exhibit B.

Our street grades are established for the center lines of the streets, elevations being given in the profile grade book at every street intersection, and at some intermediate points in long blocks. Sidewalks are set six inches above street grades as nearly as practicable. making due allowance for the grades of cross streets. This system for the street grades is very good, but renders the setting of sidewalk grades somewhat complex and uncertain.

We have about 45 miles of streets and about 90 miles of sidewalks. Fifty per cent. of the sidewalks are built of brick or stone, now the only materials admissible under the ordinances. Streets are generally 50, 60. 66 and 80 feet wide. The standard width for sidewalks is 5⅓ feet in the residence portion, and 10 and 12 feet in the business part.

WATER-WORKS.

Our water supply is taken from one large well, 40 feet in diameter and 30 feet deep, and also from a system of eight tubular wells in connction with the same. The tubular wells—8-inch tubes—are driven to a depth of about 60 feet. They are connected by a 16-inch pipe leading to the engine house. The water-works are supplied with one Worthington Duplex and one Blake pump. We have a standpipe 200 feet high and eight feet in diameter, encased in a brick wall. An elevation of the same is on exhibition here.

Our water mains run from 10″ to 4″. All mains are laid under the special assessment system, the city at large paying generally about one-third of the cost.

We have city maps on a scale of 400 feet to the inch, giving the

location of all water mains, valves, etc. The same for our sewerage and pavement systems.

ASSESSMENTS.

Until last year, all public improvements not built out of the general fund were built under the special assessment system. This system is still pretty generally adhered to, except in the case of brick pavements, stone curbing and sewers, which are characterized as a single local improvement, and in case of a street pavement executed by special taxation, wherein the abutting property pays the entire cost excepting for intersections of streets which are paid for out of the general fund.

EXHIBIT A.

SPECIFICATIONS FOR LAYING BRICK PAVEMENTS.

ROAD-BED.—By whom the road bed is to be prepared will be determined by the contract accompanying these specifications. The same shall be carefully graded and shaped to an elevation of at least eleven (11) inches below the established grade line for the surface of the pavement when completed. The City Engineer or his assistants shall set all grade stakes whereby the contractor will be governed. The road-bed shall have such convexity as shall be directed by the City Engineer. The contractor, during the grading, shall provide all earth necessary for filling, and shall dispose of all surplus excavation by placing the same in the lawns, or on other streets, as directed by the City Engineer. In order to bring the road bed to proper shape and grade, a pattern made under the direction of the City Engineer, and giving the street proper convexity, shall be continuously used as a guide for the graders. After said road-bed is properly graded and shaped, it shall be thoroughly rolled and compacted by a roller weighing at least 2 tons. After said road-bed is so shaped and rolled, there shall be laid thereon a covering of cinders of a uniform depth of at least two (2) inches, under the supervision of the City Engineer; said bed of cinders shall be thoroughly rolled and compacted, after which there shall be laid a covering of sand of sufficient thickness to grade the surface of said street to a uniform shape and give said road bed a smooth and uniform surface.

BRICK-WORK.—Upon this bed of sand, as above specified, there shall be placed a course of brick upon their flat surface with all joints broken; on said course of brick shall be spread sufficient sand to cover the entire course completely, and the same shall be well brushed into the crevices; there shall then be laid a course of brick edgewise, upon their longest two-inch surface, placed close together, with all joints broken as above specified, and broken bricks shall not be used in the upper course except when necessary to break joints. Upon the entire pavement, after it has been so laid, shall be placed sufficient screened sand to fill all crevices and interstices between the brick, the same to be thoroughly brushed into the crevices during the process of rolling. Said pavement shall then be rolled with a roller weighing at least 2 tons, all under the supervision of the City Engineer of said city.

The contractor shall use none but the best paving brick for the top course; for the bottom course he may use the ordinary sidewalk brick. The City Engineer or Public Inspector shall be the judge of all material used in the construction of the pavement, and any material condemned by them shall at once be removed from the lines of the work.

The bottom course of brick shall be laid with their longest dimensions in the direction of the street; those in the upper course shall be laid with their longest dimensions across the street in true lines or courses. The contractor will be required to discharge any unfaithful or incompetent persons employed by him upon being notified so to do by the engineer in charge.

EXHIBIT B.

SPECIFICATIONS FOR STONE CURBING.

The work herein specified includes all labor and material necessary to the complete and entire curbing of the streets as specified in the contract.

Said curbing shall be constructed of the best quality of lime,or other suitable curbing stone, free from cracks, seams, sand pockets, or other defects, and no sections of stone to be less than three (3) feet long, twenty-four (24) inches deep, and four (4) inches thick when dressed. Top edge shall be full and square and neatly bush hammered. The face also shall be neatly bush-hammered for a space of not less than nine (9) inches from the top. The ends shall be dressed smooth so as to make close joints through the full thickness of the stone not less than one (1) foot down from the top. The bottom shall be straight and shall be firmly set on blocks of flat stone, not less than twelve (12) inches by eight (8) inches by six (6) inches thick. A good quality of sewer brick may be substituted for stone as a foundation for the curbing, if in the judgment of the City Engineer there is a sufficient number of such brick used under every piece of curbing so set. The corners will be made in a true quarter circle (quadrant) with a radius of three (3) feet, and shall be constructed of one (1) stone. The corner stones will be dressed similar to the straight curbing and be free from drill holes on top.

The inlet or catch-basin will be a circular hole, hole ten (10) inches in diameter cut through the curb stone, and their location shall be determined by the engineer. Each of such circular holes must be provided with a cast-iron grate, securely and permanently fastened into the stone by means of screws or otherwise.

The full quantity of filling shall be put in from the back of each section of curbstone as it is set, and said filling shall be thoroughly rammed at the time of filling, so that the curbing may be held in place. The curbing shall be back-filled to within three (3) inches of the top; the back-filling shall have a slope of one (1) foot to one and one-half feet (1½).

It is expressly understood and agreed that this improvement shall be done in a good and workmanlike manner, and to the satisfaction of the City Engineer.

All material will be carefully inspected after it is brought upon the line of work, and any of such, which in quality or dimensions does not conform to these specifications, shall be rejected, and must be at once removed from the line of the work by the contractor. If, at any time during the progress of the work, any rejected or inferior material should be found in the curbing, or any portion of the work found to be improperly done, such material and work shall be removed and be replaced by the proper material and work, at the expense of the contractor.

* * * * * * * * * *

EXHIBIT C.

SPECIFICATIONS FOR PIPE SEWERS.

(Parties taking contracts under these specifications will be expected to live up to the requirements therein specified, without any deviation, and it is particularly desired on the part of the city that contractors shall bear this fact in mind at time of bidding, signing contracts and during the prosecution of any work that may be done under these specifications.)

All excavations shall be made to such depth and extent and division as shall be required to construct the sewer or sewers in question, and all the appurtenances thereto, in accordance with the ordinance and plans and specifications for the same as prepared and directed by the City Engineer.

The pipes used shall be vitrified, salt-glazed stoneware, of the hub and spigot pattern. All pipes shall be of good material, thoroughly and perfectly burned,

without warps, cracks or other serious imperfections, and shall be well and smoothly salt-glazed, in the best manner and shall be subject to all tests ordered by the Engineer at any time previous to their being laid.

All pipes are to be excavated for and laid true in line and grade throughout according to the lines and grades furnished from time to time. The ends of the pipes shall abut each other closely as possible when laid, so there shall be no shoulder or unevenness of any kind along the bottom half of the drain on the inside.

All pipes, previous to their being lowered into the trench shall be fitted together on the surface of the ground and matched, so that when jointed in the trench they may form a true and smooth line of tubes.

The joints, after being laid, shall be thoroughly filled with the best hydraulic cement mortar, and carefully wiped and pointed inside and out.

No walking on, or working over the pipes after they are filled (except as may be necessary in tamping the earth in refilling), will be allowed until there is at least 6 inches of earth over them.

The interior of the pipe shall be carefully freed from dirt, cement and other superfluous material of every description, as the work proceeds; for which purpose a disc mould or plate, attached to a rod sufficiently long to pass two joints from the end of the pipe last laid, shall be continuously worked through the sewer as it is being laid.

Whenever deemed necessary by the Engineer in charge, the mouth of the pipe shall be provided with a board or other stopper carefully fitted to the pipe, to prevent all earth or other substance from washing in.

Pipes having six-inch spurs, with hubs moulded thereon, for house connections, shall be furnished by the contractor and laid at such points as the City Engineer may designate in front of each building or lot on the line of the sewer. Pipes with spurs of other dimensions and hubs moulded thereon, shall be furnished and laid by the contractor for the connection of manholes, sewer-inlets, &c., as may be directed by the City Engineer or shown by plans in his office.

Unless otherwise permitted by the City Engineer the contractor shall at all times keep the back-filling a distance of at least 10 feet in the rear of the last pipe laid, and no pipe shall be covered until inspected by the Engineer or his assistant in charge.

The contractor shall provide for the flow of all sewers, drains or water courses interrupted during the progress of the work, and shall restore and make good all connections in such manner as may be directed by the City Engineer. The contractor must take care of and protect any gas, water, sewer or other pipes he comes in contact with. The invert or bottom of the trench shall be made to conform as nearly as possible to the form of the sewer pipe.

All superfluous earth left after the completion of the sewer shall be removed by the contractor and placed on other streets under the direction of the City Engineer or Street Commissioner.

Immediately after setting each piece of pipe, earth must be carefully tamped in on each side of the same with proper tools, so as to effectually prevent any displacement of the pipe, which would destroy the bond of the cement in the joints.

The back-filling must be well and thoroughly tamped for at least 6 inches above the top of the pipe; thereafter it may be settled by flooding the same with sufficient water to puddle it completely and thereby effect permanent settlement. Whenever so ordered by the City Engineer the backfilling shall be tamped in. Manholes are to be built of two rings of brick laid in cement mortar (1 part of cement to 2 of sand), as per plans and detail on file in office of the City Engineer.

All manholes and sewer inverts are to be furnished with iron grates or rings as specially shown by detail plans in the office of the City Engineer. Such grates and other castings are to be located and their number determined by said Engineer.

The sides of the excavation shall be supported by suitable planking and shoring whenever necessary in the opinion of the Engineer; and in all cases the same is to be withdrawn as the work progresses, unless otherwise ordered by the

Engineer. Whenever it is thought necessary by the Engineer the timber shall remain in the trench after the completion of the work, and the contractor shall be paid therefor by board measure at current rates.

The contractor shall, at his own expense, pump out or otherwise remove any water which may be found or shall accumulate in the trench, and shall also construct all dams or other works necessary for keeping the excavation clear from water during the progress of the work.

All material used and all work done must be satisfactory to the City Engineer, and any work done or material used not satisfactory to said Engineer shall be at once removed and work and material of required quality substituted.

Upon notice from the Ci'y Engineer the contractor shall at once discharge any unreliable or incompetent help he may have upon the work.

All stakes set by the City Engineer shall be kept uncovered and protected by the contractor. Those set in the bank for station stakes shall in no case be removed or covered, but shall be maintained aud protected as a matter of reference for the City Engineer.

The exact location of all junctions in the line of the sewer shall be carefully maintained by the contractor by means of stakes set in the bank of the trench, or otherwise, until the City Engineer shall make a record of their location.

Should there at any time arise any difference of opinion as to the interpretation of these specifications, the matter in question shall be referred to the City Engineer, whose decision shall be final and conclusive.

DISCUSSION.

Mr. Rottman.—What laws control connections with sewers and water-pipes? Are there no requirements for traps to cut off sewer gas?

Mr. Bell.—We have no city ordinances requiring them.

Mr. Enos.—Do you have no inspection of putting in connections?

Mr. Bell.—T's are put in when the sewer is constructed. These any one can attach to without city inspection, but if a connection is to be made with the sewer direct, then the city inspects it.

Mr. Rottman.—What is the size of your smallest T's?

Mr. Bell.—Six inches diameter.

Mr. Bullard.—Do you close up the ends of the T's as the sewer is being constructed?

Mr. Bell.—Yes; with brick and cement.

Mr. Wightman.—Is the surface water carried into your pipe sewers?

Mr. Bell.—In none smaller than 12 inches diameter.

SOURCES OF WATER SUPPLY.

By D. W. MEAD, of Rockford.

In the comparison of the various possible sources of supply the questions of quality, quantity, and cost of development are the principle ones to be considered. The weight to be given to each depends on the local and conditional circumstances of the community for which the supply is under consideration.

QUALITY.

Opinions differ as to just what is essential for a supply of water to be suitable for domestic use. Science as yet has furnished no wholly satisfactory criterion. It is of course easy to define and determine a water of excellent quality and as easy to recognize a very bad water, but the exact limit between the two is at the present state of knowledge hard to fix.

It would be undesirable, even were it possible, to obtain perfect chemical purity in water. Distilled water, which is the nearest approach to perfectly pure water, is quite flat and insipid to the taste, due for the most part to the absence of absorbed gases. Most people prefer a water containing a reasonable amount of matter in solution; and a large amount is sometimes found in water which is suitable for drinking purposes and even highly prized, as in the case of numerous mineral springs. For manufacturing and cleansing purposes however the absence of mineral salt in any great amount is desirable, especially the absence of the carbonates and sulphates of lime and magnesia. These substances give rise to much trouble by the formation of incrustations in boilers, and in domestic use by the formation of a "curd" with soap.

The relative influence of soft and hard water on the public health is a matter of dispute, without any satisfactory evidence either way; the effect of the presence of certain forms of organic matter in a water supply is however not a matter of conjecture.

Mankind has learned by dear experience the close connection that exists between factory and household wastes and certain forms of disease. Whether filth may produce these diseases or whether it acts merely as a nidus for their development is still in dispute. The weight of evidence shows, and the best authorities agree, that the water supply may become the cause of disease both by direct action through its impurities and as a means of transmission from some other source. Facts indicate

1st. That fresh excrementary matter may exist in small quantities in air, water, or food without proving detrimental to the individual using them.

2nd. That decaying matter taken into the system in like manner will to a greater or less extent produce diarrhœas, headache and depression, and even death, according to the physical condition of the individual, and may possibly give rise under certain conditions to some of the zymotic diseases.

3rd. That filth, contaminated by discharges from zymotic patients, is capable of producing like diseases in others.

4th. That some individuals may by usage become accustomed to a state of filth and live in apparent health while a person accustomed to pure air, water, and food will feel the evil effects of such conditions at once.

Chemical and microscopic analysis, together with a careful examination of the geological and topographical features which influence the source of supply will usually lead to a satisfactory knowledge of the present condition and the possibility of future pollution, and may suggest precautions necessary to prevent pollution.

The most important analysis of the chemist is to determine the organic matter, but as the source of organic pollution, a very important factor, can not be determined by analysis a considerable doubt must exist concerning the utility of the investigation.

The following standards of purity have been recommended:

1st. Prof. Wanklyn determines the albuminoid ammonia, and classifies waters by the parts of albuminoid ammonia per 100,000 as follows:

Waters of great organic purity	0 to .005
Safe waters	.005 to .010
Impure waters	Exceeding .010

2nd. Dr. Frankland determines by combustion the amount of organic carbon and nitrogen and claasifies waters by the amount of organic carbon per 100,000 parts.

	Upland surface water.	Deep water.
Waters of great organic purity	0.0 to 0.2	0.0 to 0.1
Waters of medium purity	0.2 to 0.4	0.1 to 0.2
Waters of doubtful purity	0.4 to 0.6	0.2 to 0.4
Impure waters	Exceeding 0.6	Exceeding 0.4

3rd. Drs. Letherly and Tidy employed what is known as the oxygen process by which the oxygen required to oxidize the organic matter is ascertained. The waters are classified by the amount of oxygen required in 100,000 parts.

Water of great organic purity	0.00 to 0.05
Water of medium purity	0.05 to 0.15
Water of doubtful purity	0.15 to 0.21
Impure water	Exceeding 0.21

The New Jersey State Board of Health has issued the following directions for making simple tests of the purity of drinking water:

"*Color.*—Fill a clean, long bottle made of colorless glass with the water; look through the water at some black object; the water should appear perfectly colorless and free from suspended matter. A muddy or turbid appearance indicates the presence of soluble organic matter or solid matter in suspension.

"*Odor.*—Empty out some of the water, leaving the bottle half full; cork up the bottle, and place it for a few hours in a warm place; shake up the water, remove the cork, and critically smell the air contained in the bottle. If it has any smell, and especially if the odor is the least repulsive, the water should be rejected for domestic use. By heating the water to boiling, an odor is evolved sometimes that otherwise does not appear.

"*Taste.*—Water fresh from the well is usually tasteless, even though it may contain some putrescible organic matter. Water for domestic use should be perfectly tasteless, and remain so even after it has been warmed, since warming often develops a taste. If the water at any time has a repulsive, or even disagreeable taste, it should be rejected.

"As some waters of a dangerous quality fail to indicate their impurity either by smell or taste, what is known as the Heisch test is of value: Fill a clean pint bottle three-fourths full with the water to be tested; add to it a half-teaspoonful of clean granulated or crushed loaf sugar; stop the bottle with a glass stopper or a clean cork, and let the bottle stand in the light in a moderately warm room. If in twenty-four or forty-eight hours the water becomes cloudy or milky it is unfit for domestic use. While cloudiness in the water after standing certainly indicates unfitness for use, yet a negative result does not prove the water to be good; because the test often fails to indicate organic matter really present, if phosphates are absent."

The chemical examinations of water should include a full quantitative and qualitative analysis, as a judgment based on but one item is more liable to be erroneous. Care should be taken in the selection of samples for analysis, especially is this the case in surface waters where the season may seriously affect it by flood or drought.

Chemical analysis, as has been before indicated, to be of value must be taken together with a microscopic examination and a study of the local conditions; for as has been shown the opinion of the chemist is based on the presence of organic matter which may or may not be injurious according to its nature and origin. Many of the rivers in our timber regions are so highly impregnated with organic matter as to strongly color their waters, yet the continued use of such water does not prove injurious. So we see in Dr. Frankland's process, above given, a considerable allowance is made in his standard on account of the origin of the supply. The presence of chlorine is also considered a suspicious circumstance in most waters as indicating a probable sewage contamination, yet near the sea or in salt countries it cannot be so considered.

There is in these determinations a wide field for microscopic and biological study and this method is rapidly gaining prominence. Pure waters under the microscope are entirely free from animal or vegetable organisms; while polluted waters often swarm with low forms of organisms, natures scavengers. Their presence or absence

is however no conclusive proof of the wholesomeness or unwholesomeness of a water but when studied and classified they furnish evidence of great value, which we may expect to become more valuable as the development of this line of science proceeds.

QUANTITY.

The available quantity of water is also an essential feature of a supply. An under estimate of the amount of water necessary or an over estimate of the amount obtainable from a selected source often leads to much trouble and expense.

The consumption of water depends so largely on local conditions and circumstances, on the habits and pursuits of the people and the manifold purposes for which it may be used that any estimate can only approximate. Not only probable needs but future possibilities should be taken into account in the selection of a source; and that source which admits of future enlargement should be looked upon most favorably unless other considerations outweigh it. From statistics of places already supplied we may judge in a general way of the probable needs of the community for which provision is to be made. In so doing the considerations before mentioned should have careful attention. The needed supply for domestic purposes will vary from five gallons per head, where it is used merely for drinking and culinary purposes, and impounded rain water is used for cleansing purposes, to twenty-five gallons per head, where it is used for all domestic purposes including water closets, bath rooms and laundries. Where manufacturing uses is an item to be considered an estimate of from five to twenty gallons per head on the entire population according to the nature and magnitude of the manufactories should be made. The use of water also increases with the population, for as a community becomes more and more compact the use of wells and cisterns becomes less and less frequent or possible An approximate average for the northern states would seem to indicate in general a daily demand about as follows: For a population up to 5,000, 25 to 30 gallons per head; 5,000 to 10,000, 30 to 45; 10,000 to 20,000, 40 to 50; 20,000 to 30,000, 45 to 55; 30,000 to 50,000, 50 to 75; upward of 50,000, 60 to 100. Much of this, especially in the larger places, is wasted by improper use and poor fixtures, and could doubtless be saved by proper regulations and careful inspection.

The daily average varies with the season of the year, the day of the week and the hour of the day. The occurrence of fires also effect to a very large extent the supply, as they are as liable to occur during the maximum consumption as at any other season. Without going into detail it is found that the maximum draught on any supply varies from twice the average amount (for the ordinary maximum caused by increased domestic consumption) to ten times the average amount (due to the demands for fire service).

In Illinois the rain-fall varies from 30 to 50 inches per annum. On account of evaporation and other losses not more than

forty per cent. of the annual yield of a water-shed can be utilized for the supply.

In creeks and rivers where there is any question concerning the amount furnished during the lowest water, the stream shoul l be gauged and the amount of available water accurately ascertained In springs, wells and ground-water supplies, the only method is the actual test of the source by pumping.

In supplies drawn from wells it must be remembered that a single well sunk in the water-bearing strata and tested cannot be taken as the unit supply furnished by a number of wells from the same stratum. For an increase in the number of wells is apt to decrease the flow of each individual well and additional wells in the vicinity will not increase the flow.

SOURCES AND DEVELOPMENT.

In general, sources of supply may be briefly classified as follows: 1st. Rain or surface waters impounded in cisterns or tanks for domestic use, or in artificial or natural reservoirs for public supply. 2nd. Rivers and creeks. 3rd. Ground waters. 4th. Springs. 5th. Deep-seated waters.

I. Rain or Surface Waters.—Impounded rain water differs in quality and character with the circumstances attending its collection. In the open country, away from the smoke and dust of cities or the poisonous exhalations of manufactories, rain water as it reaches the earth is undoubtedly pure and wholesome; not pure however in the chemical sense of the word but only comparatively speaking, for even here it gathers traces of organic life and minute particles of various kinds which it finds floating in the air as it descends.

To how much greater extent must we expect to find this pollution carried as we approach the urban or manufacturing districts. Here as commonly collected for domestic use it often contains a large amount of soluble and suspended matter. This consists of dust and soot together with the droppings of birds and such other accidental deposits as are sure to gather, to a greater or less extent, on the broad roof of a residence. The river pollution commissioners after an investigation of numerous samples of rain water, collected in various parts of England, declare their belief that as ordinarily collected it is often polluted to a dangerous extent by excrementitious matter and is rarely of sufficiently good quality to be employed for domestic purposes with safety. This is more strictly the case as the community is more densely settled. But in country districts with proper care, in letting the first washes of the roof waste aud providing suitable receptacles properly cleaned at suitable intervals, the water may be regarded as suitable in all regards for household use. Even in cities it is often desirable, unless the public supply is more than ordinarily soft, to collect the rainwater for cleansing purposes.

Rain water impounded on a large scale either naturally as in ponds and lakes or artificially in reservoirs built to receive and retain

the water from a selected water-shed, gives much better results than in ordinary domestic supplies.

Ponds and lakes have advantages over rivers as sources of supply in that they are less likely to be rendered turbid from floods and do not offer the facility and the consequent temptation furnished by rivers for the cheap and ready means of disposal of the waste matters of civilization.

On the other hand the still waters of ponds and lakes offer greater facilities for the growth of many minute vegetable organisms. The following extract from the nineteenth annual report of the Massachusetts State Board of Health will give a general idea of this source of trouble and some of the methods of remediating the same.

"Three classes of plants are found in our ponds and reservoirs. First, those which are fixed in the basins, such as the common pond weeds and a few filamentous algae. Second, those which are suspended in the water, but do not readily decompose, the common green algae (desmids, diatoms, etc.,) and duck weed. Third, those which are suspended in the water and are readily decomposed, the blue green algae (cœlosphærium, anaboena and clathrocystis). Plants firmly fixed in streams and basins are harmful mainly in affording a lodging place for the development of plants belonging to the groups two and three above noted."

"In basins having much fluctuation of level, plants of the first group may injure the water by their death and consequent decay. The floating plants of the second group are injurious, since, after a long carriage through a closed conduit or in continued hot weather, they die and are decomposed. In Boston water, taken from a tap, they are usually dead; in Cambridge they are usually alive in the water taken in the same way, and offend only the sense of sight."

"The members of the third class multiply very rapidly and secrete a jelly, which together with the plant, readily undergoes decomposition. These plants usually decay in the taps only by a few fragments.

"Of animal, two classes may be mentioned: The fixed or sessile forms, and the free swimming. Of the latter the Entomostraca are the troublesome forms, and these mainly in the hot weather, when the rate of reproduction is very high. Of the sessile animals two are noteworthy, the fresh water Sponge and the Polyzoa. The latter usually encrust the gates and open ends of pipes. One gelatinous form lives in the ponds, sometimes free, sometimes attached."

"The comparatively small number of the Polyzoa and their hardiness render them generally less important than some of the other organisms. The Sponges are undoubtedly the most troublesome of the animals found in water supplies. They seem to have established themselves in the Boston and Charlestown systems, but are not found in the Cambridge system. They are now conspicuously absent in the sources of Boston's water supply."

"Some of the lines upon which relief from the nuisance occasioned by these organisms may be sought are the following:

Fixed plants may be cleared from ponds by the usual methods of raking. Improvements of the ponds by deepening and removing the loam will probably do much to check the growth of plants in groups two and three." The preliminary report of Mr. Parker in the same volume "demonstrates the value of covered reservoirs as a protection against the vegetable life which seems to be the ordinary source of the disagreeable tastes and smells so common in our ponds and reservoirs."

Experience also teaches that depth in a reservoir is a source of safety, as many plants will flourish only in shallow water which is easily warmed by the sun's rays.

We may regard surface waters, when properly chosen, well maintained and properly guarded from pollution as one of the best sources of supply, especially where soft waters are desirable.

II. Rivers and Creeks.—In the general character of the water, rivers and creeks do not differ materially from the waters of lakes and ponds. Their waters, however, are liable to a greater variation in quantity on account of seasons of rain or drought.

Many rivers originate in pure mountain springs and constantly receive additions to their volume from ground water and tributaries, while they lose more or less by evaporation and the sinking of portions of the water into porous strata. The water in its passage takes up more or less of organic and mineral matter, depending on the nature of the country through which it passes.

The principal trouble met with in the use of this source of supply is that already mentioned,—the use of rivers as the common sewers of the country. In some sections so great has become this abuse that the rivers are not only unfit for the public water supplies but are become a public nuisance and a detriment to health.

The following extract from the report of Capt. Thos. W. Symons on the water supply of Washington, is applicable to all streams used as a public water supply:

"As a source of water supply the Potomac has the inherent defects which accompany most river sources, and these defects become more and more marked with the advance of civilization. It flows through rich valleys occupied by great numbers of people with their flocks and herds. The lands are highly cultivated, and have been for many years, and the use of fertilizers does and must increase with time. The cutting away of forests and clearing up of the mountain slopes bring about climatic changes, increasing the violence of storms and freshets. All injurious organic matter scattered about the land in the shape of fertilizers and decaying vegetable and animal matter is much more readily washed into the running streams, and finds its way to the source of our water-supply. The floods also gather larger amounts than formerly of the organic matter of the soils through which they flow. The increasing size and number of

towns, the sewerage from which mostly finds its way in some form or other to the Potomac, are elements to be considered in discussing the defects of our water supply and their remedy. During the summer months, when the rains are few, light, and of short duration, the Potomac is a comparatively clear stream, and the water supplied to the city is of very excellent appearance. But in the autumn, winter and spring, the period of the year when storms and freshets most prevail, the water becomes more or less impregnated with impurities of all kinds, and the supply as it reaches the city is repulsive in appearance, fills the minds with misgivings as to its wholesomeness, is a drawback on the growth and development of the city, is deleterious to health and morals, and is a source of expense and worriment to all householders who are obliged to keep filters for its purification."

The following quotations from an English report will apply as well to many of the large streams in the thickly settled portions of our own country.

"The rivers are abused by passing into them hundreds of thousands of tons per annum of ashes, slag and cinders, from steam boilers, furnaces,iron works and domestic fires,by their being made the receptacle to a vast extent, of broken pottery and worn out utensils, street sweepings, etc., by spent dye-wood and other solids used in the treatment of worsteds and woolens; by hundreds of carcasses of animals, as dogs, cats, pigs, etc., which are allowed to float on the surface of the streams or putrefy on their banks; and by the floating in, to the amount of very many millions of gallons per day, of water poisoned, corrupted, and clogged by refuse from mines, chemical works, dyeing, scouring, slaughter house garbage and the sewage of towns and houses." So great has become the pollution of this source of supply that in England and in some of our eastern states special laws against the pollution of the public waters have been enacted. In some places by an unwarranted dependence in Providence and the laws of nature, communities have been able to utilize supplies not much better than that described above.

That running water will to some extent purify itself there can be no doubt but the extent to which this purification will take place is much less than is commonly supposed. Undoubtedly many streams seem to be more pure as the distance from the source of pollution increases. The cause of this is oxidation, deposition, and dilution, besides consumption of a certain amount by fishes, microscopic animal and vegetable life.

The Blackstone River receives nearly all the sewage of Worcester, and a few miles below the city is very foul, but at Blackstone it has become quite different, as shown in the following table. In this distance it receives however several unpolluted affluents.

EXAMINATION OF FLOWING STREAMS, MASS. BOARD OF HEALTH.

(RESULTS EXPRESSED IN PARTS PER 100,000.)

LOCALITY.	Ammonia.	"Albuminoid Ammonia."	Solid Residue. Inorganic.	Solid Residue. Organic and Volatile.	Solid Residue. Total at 212 F.	Chlorine.
BLACKSTONE RIVER, (1873.)						
A few miles below Worcester.	0.370	0.041	9.00	2.70	11.70	1.60
At Milbury, about 5 miles lower down the river.	0.025	0.022	3.30	3.20	6.50	0.68
At Blackstone, about 20 miles lower down stream.	0.005	0.015	3.88	2.20	6.08	0.52
	0.004	0.016	2.76	2 32	5.08	0.40

Dilution undoubtedly plays the most important part in river purification and even where there are no tributaries the river receives more or less from the ground waters, the sewage of course becoming more and more diluted.

It must be remembered in the consideration of these sources of supply that the poison or germ by which certain diseases are communicated cannot be detected by chemical or microscopic examination and that even a remote possibility of such contamination should be guarded against.

III. Ground Water.—Ground water is water which sinking into pervious ground has reached an impervious formation and formed an underground lake or river. In the first case the water is nearly or quite stationary, fluctuating only with the amount of rainfall and with the amount used by roots of plants, evaporation or through wells. In the latter case the ground water has a movement similar to, though less rapid than, that of ordinary surface rivers.

It is from this source that the ordinary well water for domestic supplies is obtained and it is also this water that is peculiarly liable to receive from certain sources a large amount of the worst form of pollution. In farm drainage lines of tiles are sunk in the ground and are expected to drain the soil a certain distance in all directions. Almost identical with this we sink wells into the water-bearing strata of the soil and expect to receive and do receive the water from a considerable distance depending of course on the direction and amount of flow of the ground water. Is it not strange then, that we should find also located in the same soil, sometimes at very short distance away from the sonrce of water supply, leaking privy vaults and cess-pools? Not only this but we are sometimes told how long a cess-pool has been in use without ever filling up and almost at the same time the never-failing supply of sparkling water on the same lot is mentioned. We shall find few, however, who trust so deeply in

the eternal fitness of things that they can feel like the man who was angry beeause salt was thrown in his privy vault and spoilt his well water.

When an abundant supply of water can be drawn from the subsoil, a common supply from one or a series of wells for the whole community is much better than individual supplies for each household, for in this case more care can be taken in the selection of the site and its protection from pollution.

The writer has in mind one place where a well sunk for the utilization of the ground water drained the cess-pools and vaults for some distance around, and after an expense of some twenty thousand dollars had to be abandoned.

In the development of a ground-water supply various investigations should be made. The direction and flow of the ground water should be determined and a thorough investigation of possible sources of pollution should be made. One of the most favorable locations for the utilization of this source of supply is in the immediate vicinity of a water-course, for at such place the direction of flow is usually toward the water-course and hence easily determined. The proximity of the water-course is also apt to make a more reliable supply, for if the ground water becomes low the river will supply the deficiency by percolations through the bank.

To utilize this source of supply large wells are frequently sunk into the water-bearing stratum from which the water is pumped direct. In other cases iron pipes of various diameters are driven or bored into the ground. On the bottom of these are screwed or fastened strainers which allow the water to percolate into the tube from whence it is drawn by pumps. In this last method a number of wells are usually constructed and connected together in one system, a reservoir being sometimes used in this connection.

Another method is to construct lines of pervious pipe into which the water may percolate and so flow to the pumping well. Or a filter gallery may be constructed in the water-bearing medium from which water may be pumped.

In response to a request for advice from the water commissioners of the town of Ayer, the Mass. State Board of Health replied as follows (*vide* 19th annual report, page 9):

"In response to your request to know whether subsoil waters have been found more satisfactory than pond waters we give you a summary of results reported to the board up to the present.

"Of seven places which collect ground water, and store it in open earthen and masonry reservoirs, three report trouble and four report no trouble. Of fourteen places so collecting and pumping into iron masonry tanks, some of them covered, two report trouble, and one of which shows by analysis to be poor before being stored, and twelve places report no trouble. The surface water supplies, including both ponds and storage reservoirs, have given more trouble east of the Connecticut River than west of it in the mountainous region. Up

to the present time the ground-water supplies have given less trouble than surface-water supplies and the ground-water supplies are far more satisfactory when used directly after being drawn or with as little storage as practicable.

The experience of the Mass. Board of Health will find verification in all places where proper care has been taken in the selection of the location of the source of supply.

IV. Springs as Sources of Supply.—When rain falls in the higher elevations on pervious ground or rock, the water sinking into the surface sometimes again appears at lower elevations as springs.

Water from such sources differs widely in character, depending of course on the amount and nature of the substances dissolved in its course from the original gathering ground. If suitable springs can be found which do not contain too much mineral matter and which afford a constant supply they may be regarded as one of the best sources of a public supply.

V. Deep-Seated Waters.—As before stated the ground waters occupy the strata between the surface and an impervious stratum which acts as a bed to the subterranean lake or river. Under this impervious stratum there is commonly found pervious strata which may contain water. This water may and usually does differ more or less from the ordinary ground water, and is ordinarily much less liable to pollution. The reason of this is that its source is usually a greater distance away, commonly at the exposed outcrop of the containing strata which may be several hundred miles distant.

When the source of the water is at a point higher than the point of development of the supply the chances are favorable for an artesian well. Artesian waters are liable to be among the hardest of natural waters, inasmuch as the waters of these wells sometimes travel great distances from their sources to the point of flow, and of course gather much mineral matter from the rocks through which they flow.

The principal danger of contamination of deep wells is due to the not uncommon practice of sinking wells into these porous strata, not for obtaining water but to dispose of liquid wastes.

Great care should be taken in the location of deep wells to see that there is no chance for pollution from such sources.

The method of development of these supplies depends of course on the characteristics of the strata in which they are fouud. In the flowing artesian well, the waters may be received into a reservoir or may be pumped direct from the well. In the latter case the suction should reach down into the well some thirty feet, rather than be connected directly to the casing of the well. If the impervious stratum is near the surface the ordinary drive or bored well with strainer on the end may be sunk; and if the water is not more than twenty feet from the surface the pumps may be attached at that point. When the distance to the water is greater than this the pumps may be lowered ten or fifteen feet or more below the ground surface, and the

supply reached by the suction of the pressure pumps. When, however, as is often the case in non-flowing artesian wells and in other deep-seated waters, the ordinary suction pumps cannot be lowered so as to reach the water, special pumps, which are usually termed deep well or artesian well pumps, must be applied to each well. These pumps are so arranged that while the steam cylinder is at or near the surface, the water cylinder may be at a hundred or more feet below the surface.

Each source of supply has its advantages and disadvantages. In some localities a single source is the only one possible. In others several sources are feasible. It remains for the engineer to examine carefully every possible source, to weigh justly all factors on which the success of the supply depends and to determine as closely as possible the best source available for the community when all local considerations are taken into account.

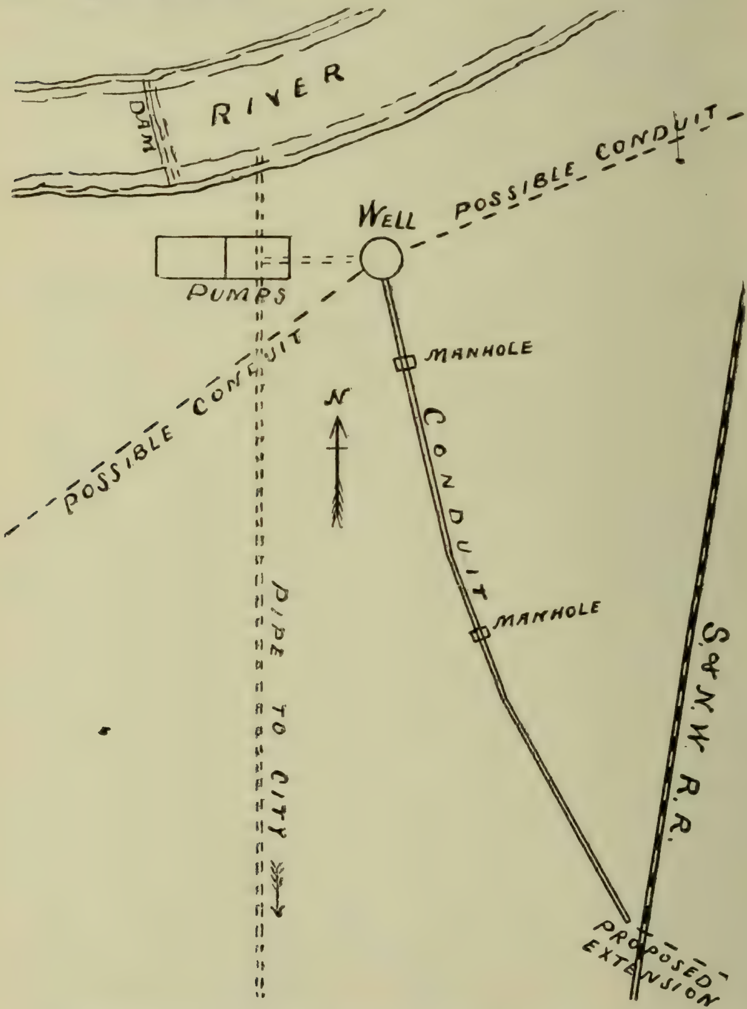
THE SOURCE OF THE WATER SUPPLY OF THE CITY OF SPRINGFIELD.

By S. A. BULLARD, of Springfield.

At the time of the construction of the water-works of the city of Springfield, the Sangamon river formed the source of supply. The pumping station is located near the river at a distance of about four miles from the city. The pipes run directly from the station to the reservoir, which is located at the north city limits. Upon the reservoir depends the force for water during times when the pumps are at rest. The pumps work fifteen or sixteen hours per day, ceasing at ten or eleven in the evening and commencing at seven in the morning. They rest also on Sundays. The suction pipes of the pumps were fed directly from the river and the ends of the pipes were so placed that at the lowest stages of water the pumps would draw air. The water commissioners were obliged to construct a small dam below the pipes so as to raise the level of the water at the low stage. Again, the furnaces are so situated as to be threatened with deluge at times of high water, so that instead of being between two fires, as the popular phrase is, the department was literally between two waters.

The quality of the water from the river for many years has been at times very objectionable. The distillery located at Riverton a few miles above the pumping station has always been a source of contamination. At times of low water the fish in the river below the distillery have succumbed to the pollution and turning themselves belly up to die easily, have floated quietly past the pumps. But for the good quality of the sieves furnished by the commission-

ers, the capital city people could have had buffalo or catfish stew for breakfast, simply by turning the hydrants into their dishes. Just how many of the city's people followed the example of the fishes and ended their earthly existence because of drinking vitiated river water, perhaps only the doctors could disclose. Certain it is that for many years none of the people of the city ever drank hydrant water. It was used for putting out fires, washing buggies, sprinkling yards and for general barnyard use.

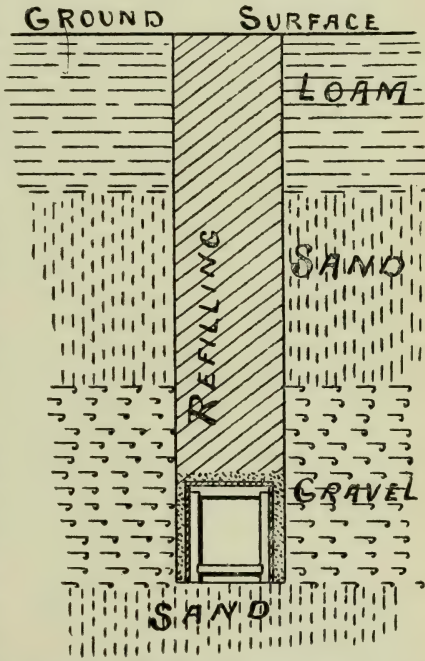


As the growth of the city proceeded, a greater supply of water became necessary. At times of low water the full amount of water

could scarcely be obtained from the river and another source had to be sought.

A large well 50 feet in diameter was sunk about 100 feet from the river bank. This well was curbed with a heavy brick wall laid in cement, as the well was being dug, the curb settling down as rapidly as the excavation was performed. From previous borings it was found that a gravel stratum nine or ten feet deep with abundant water would be found about thirty feet below the surface. It was the aim to make the bottom of this stratum the bottom of the well, but in the actual construction the well was dug several feet below into the sand and the curb was hopelessly sunk into the sand before being noticed, thus entirely cutting off the water from the gravel stratum. Holes were cut through the walls at points into the gravel, but no great abundance of water appeared.

The past summer an effort was made to increase the water producing power of the well and a subterranean duct in the water-bearing stratum was constructed. The accompanying section shows the construction.



The duct is four feet wide and five feet high and is walled with 3-inch elm planks supported by 3″ × 5″ oak ribs. The covering on top is also of the same wood while the bottom is left with no covering. Oak stays between the ribs supporting the side curbing pass from side to side about five inches above the bottom, thus allowing as little hindrance to the flow of water as possible.

The practical construction consisted in digging a deep trench of sufficient size and to a depth reaching the bottom of the gravel stratum, and then enclosing the lower part of the trench with wood as described above. On the wooden conduit thus constructed a layer of broken stones is placed to a depth of six inches to one foot and any space at the sides between the banks and the wood curbing is filled in likewise; then the earth is promiscuously dumped in as in ordinary sewer work.

This water duct was constructed to a length of nearly one thousand

feet in a direction away from the river, as shown in the sketch, and connected with the well through a hole in the well's curbing. The duct has two man-holes, one near the middle of its length and one near the well, so that if it be necessary at any time to examine or repair the work, pumps may be directly applied to the water after cutting off communication with the well.

The product of this duct at its completion was about 1,500,000 gallons per day; and as the daily consumption is two and one-fourth million gallons, the hope is expressed that the well and duct together may be sufficient in ordinary seasons to supply the present needs of the city.

This duct may be indefinitely continued so that its length may be two or three thousand feet; and other ducts may be made in other directions from the well and of such a length as to furnish water to a city of 300,000 people. The quality of the water is excellent, and it is now recommended by the city physicians for use by the people for drinking and cooking purposes in preference to well waters, even in outer residence portions of the city.

The citizens hail with gratification the induction of pure water through the city pipes and an ordinance has lately been introduced in the city council enabling the water commissioners to extend the gallery the coming summer at least one thousand feet further.

SEWAGE DISPOSAL.

By PROF. A. N. TALBOT, of Champaign.

It is not the object of this paper to give more than a general description of the different systems of sewage disposal. Any scientific discussion or any thorough treatment of details would enlarge it beyond the limits of such papers.

Whatever may be the advantages of the various pneumatic systems of sewerage, the almost universal adoption in this country of the water-carriage system of sewerage—the system in which the wastes are transported through the agency of water flowing through conduits—makes it the only system to be considered. Its cleanliness, its comparative freedom from requiring attention and policing, especially with the customary extravagant use of water in our cities, make it the most desirable system.

The question of the method of disposing of this sewage, however, is quite a serious one and will yearly become more prominent. In the next half century the problem will puzzle more than one Illinois town and tax them heavily for construction and maintenance of sewage disposal works. In sparsely settled regions the matter has been neglected, but increase of population and pollution of the soil will force the recognition of this need.

The decision of the proper method of disposing of the sewage can not be absolute—a system suitable or desirable for one location will not be best in a town whose surroundings and necessities are different. Every case must be treated by itself and that system chosen which will most nearly fill its requirements.

The method of disposal is very likely to be decided on the grounds of comparative costs, provided at least a fair degree of sanitation is assured. So the sanitary question is secondary to the financial one, and however excellent the merits of a scheme from a sanitary point of view the excessive cost may make its adoption entirely impracticable.

DISCHARGE INTO STREAMS.

The usual method of disposal is to turn the sewage into some water-course. This is cheap, easy, convenient, for there are not expensive works to construct and maintain. From a sanitary point of view the question will be, does this disposition contaminate the water supply of towns below, and if the stream is not used as a source of water supply, will a nuisance prejudicial to the health and comfort of the adjacent inhabitants be created?

The first question then is, when does sewage contaminate water supply, or rather, when is such supply allowable if sewage has been discharged into the stream? It would be impossible within the limits of this paper to treat this question completely or scientifically. Aside from the mass of details that would be required, the question depends so much upon the circumstances of the particular locality that no general treatment can be given. Besides, even the best informed and most thoroughly experienced men disagree radically on the subject, and after all, in the present state of science, much of our knowledge is merely a matter of opinion. Chemical analyses give similar results for potable and impure water. Traces of organic matter may not be sufficient cause for rejection. Biological examination has not reached the stage of perfection that will enable its tests to determine the value of the water. The dreaded disease germs have evaded any certain test. Much progress has been made in this direction in the past few years, and valuable results may be expected soon.

In an investigation in connection wlth the water supply of London, extending over twenty years, it was established that although the Thames above London received the sewage of a million of people with a dilution of perhaps one in forty, the water supplied was safe and healthful. Sewage when mixed with twenty times its volume of running water, after flowing ten or twelve miles, was said to be absolutely destroyed. Some testimony gives the amount of dilution and the distance of necessary flow considerably less. The sewage was so thoroughly oxidized that no trace of it could be detected in an unoxidized condition. In smaller streams, the effect of a similar pollution might be more dangerous, as it would be concentrated. The average flow of the Thames at the point considered was about 75,000 cubic feet per minute.

Recent investigations give greater prominence to the danger of stream pollution. While the above authority gave as potable water sewage diluted 20 times in clean water and exposed to the air for a few miles, a mixture with 60 parts of water(and with the extremists, 300) is held by distinguished engineers and scientists to be necessary.

The belief is growing that in the smaller streams, after making due allowance for exaggerated statements concerning disease germs, drinking water should never be taken when the streams have been contaminated with human excrement, or at least before choosing such a supply the most careful examination of the water, continuing over a long period, should be made. In general, however, other sources of water supply, deep wells, etc., must be chosen.

Aside from the question of water supply, the desirability of such a method of discharge of sewage will depend upon the quantity, current, etc. If the current of water moves at the rate of a mile an hour or more, most of the solid particles kept in suspension by the motion of the water will be carried away to settle to the bottom of

the stream when a quiet place is reached. When these particles are distributed over a wide area, they will be oxidized or deodorized so that no nuisance will result. The putrescible matter in solution will be oxidized in transit, and no putrefication is noticed.

Note, however, that the crude sewage must be diluted many times,—perhaps 20 or more—and that the current shall be sufficient to carry away and distribute all suspended particles, in order that no nuisance will follow. Although a stream may usually fulfill these conditions, times of drought may not permit such discharge. Besides, most small streams in their ordinary or low-water stages have places where slack water or eddies will cause an objectionable deposit.

The extravagant use of water in towns supplied by water-works is an advantageous feature of such a method of disposal, however expensive the use of three or four times the water actually needed may be. The crude sewage is thus so diluted that it may be discharged into a stream with much less danger.

Small towns that are situated on rivers where the water supply is obtained elsewhere will continue to find the discharge into water their best way. Indeed in most cases it will prove advantageous to change the water supply at a considerable cost, rather than seek some other disposition of sewage.

The condition of the Illinois River has long been very objectionable. The pollution of the Des Plaines and Illinois rivers extends as far as the mouth of the Fox in summer low water, and occasionally to Peoria (158 miles). Chicago herself is nearing a critical condition, for her water supply is in danger of pollution and the river is always unbearable. Only a project of a 160-foot canal, furnishing 300,000 cubic feet per minute to the Des Plaines, will give the necessary relief to the situation in Chicago and the adjacent towns. Even with Chicago sewage excluded and no water received from Lake Michigan, the Illinois river would be badly polluted by the numerous growing cities along its banks and those of its tributaries, the Fox, etc., as the low water in '87 was probably not 60,000 cubic feet per minute in addition to the amount received from Chicago. This small amount of itself, flowing in so large a channel, with a small current, and receiving the sewage from so many large towns, would cause a nuisance almost as great as the present one, so that independent of Chicago sewage the condition of the river would not give potable water and would at times be unbearable.

To prevent the pollution of a water supply, as well as to avoid a nuisance, a method of purification of the sewage has been found necessary in some localities, especially in thickly settled communities. This is true in Europe. England has taken the lead in sewage purification and the experience and knowledge gained there is our best authority. Within a few years, several towns near our eastern seaboard have put in arrangements for some systems or other of sewage purification. Aside from some of the simpler and more imperfect

methods, as subsidence and coarse filtration, the principal methods in use are clarification by the use of precipitants and irrigation.

PRECIPITATION.

As the solid matters in suspension are instrumental in causing a nuisance, the part in solution being easily oxidized by contact with the air, etc., the sewage may be clarified by the use of a precipitant. A variety of chemicals have been used. Lime has proved as satisfactory, especially financially, as any. About one ton of lime is necessary for each million gallons of sewage, The lime, ordinary quicklime, is first slaked by adding to it an equal weight of water. It is then ground in a pugmill, then mixed with water, producing a cream of lime like ordinary whitewash. This is thoroughly mixed with the sewage by passing both through a tank having an arrangement to agitate the liquid and then the mixture flows to another tank. Either of two methods may be used: 1. Use the several tanks separately, allowing the sewage to remain in a tank a half hour, when the precipitate having settled the clear liquid may be drawn off. This requires a number of tanks so that while some are filling others may be at rest and still others emptying. 2. Arrange the tanks so that the sewage flows continuously through the several tanks, the size and slope being such that the time of passing through will be several hours. Any tank must be capable of isolation in order that the sludge may be removed.

The precipitate, a semi-fluid black mud, called "sludge," is almost as hard to dispose of as the crude sewage. About one ton of sludge will result from 50,000 gallons of ordinary American sewage. Its nature is such that it is liable to putrefy when exposed to the air and heat. It is of little value as a fertilizer. Sometimes it is pumped on to porous land where it is left to drain and harden, after which it is buried or carted away for fertilizer. Recently it has been pressed by a machine of peculiar construction and the cakes are sold to farmers. The other processes, using sulphate of alumina, salts of lime and iron, or alum, blood and clay, are quite similar in operation but are more expensive.

Sewage is not wholly purified by any process of precipitation, and unless delivered into a very large body of water will pollute it as a source of supply. When discharged into a large stream not used for domestic purposes, the purification is quite sufficient.

The system of precipitation is quite expensive. An expensive plant and a force of workmen are required to operate it. Often the sewage has to be pumped. It is estimated that the cost in this country would be about seventy-five cents per capita per annum. This, for a city of 10,000 inhabitants, would amount of $7,500 per year, in addition to the cost of pumping.

IRRIGATION.

Purification by land may be classed as Irrigation and Intermittent Downward Filtration. In the former a sewage farm is devoted to

the disposition of the sewage, which is turned on much as irrigation is performed in dry countries. The particles in suspension are removed by filtration and the soluble impurities are oxidized by being brought into contact with the air contained in the earth, the growth of vegetation aiding in the transformation. Earth is an excellent deodorizer, and with suitable soil properly drained and with no chance for an excess of sewage on the area, the purification is complete, and the water that drains away will be pure and harmless. The most suitable soil is a light porous sandy soil, though even dark heavy soils have been used. Clay has been used, but the area required is much larger and must be thoroughly tiled. The porous soil should extend down five or six feet—the ground water should stand no higher than this—and tile when used should be at this depth. The sewage may be delivered through underground pipes working under a small head to hydrants in different parts of the field, and thence distributed over the adjacent areas by a hose, or by small ditches as in ordinary irrigation. Sometimes the land is prepared in ridges about two feet apart and the sewage allowed to run between these.

The area required depends largely upon the soil, crops, rainfall, drainage, etc. The tendency in Europe is to increase the acreage. While formerly as little as one acre to 150 persons was allowed, recent practice increases the area to one acre for each 50 to 75 people. The founders of Pullman settled on one acre to 100 persons. That this amount is not conducive to proper tillage of the soil is shown by a comparison with farm irrigation in Colorado. There one cubic foot per second is given to irrigate from 50 to 55 acres. Counting sewage as 100 gallons per capita per day, this would be equivalent, to the sewage of 120 to 125 people per acre. Here where rain alone gives the soil excessive moisture, and where the soil is far less porous and bibulous,a much larger area could be used with advantage. A great drawback to the success of sewage farming is that the waste has to be thrown on the ground whether the crops need it or not. Too often the financial success of the farm is made subordinate to the purification of the sewage.

Sewage disposal by irrigation is expensive. Besides the cost of pumping, the interest of the investment in the farm, repairs to pipes, etc., will be considerable. Intelligent supervision is also required. Not often do sewage farms pay the cost of operation, to say nothing of the other expenses. It has been reported that the farm at Pullman paid $3,000 above expenses one year. That year must have been exceptional both in crops and in maintenance expenses, as the best information I can get from those who know is that the cost during the last five years has averaged many thousand dollars more than the receipts. It could hardly be otherwise, for the sewage farmer competes under many disadvantages.

A short description of the Pullman system may be of interest: The sewerage system of the village of Pullman is what may be

termed the separate system in the best sense of the term. The storm water is carried off in sewers and drains, which discharge into Lake Calumet. The house drainage and the waste from the shops are transported through ordinary vitrified pipe sewers which empty 16 feet below the surface of the ground into a cistern of 300,000 gallons capacity. From this, the sewage is forced through a 20-inch iron main to the sewage farm three miles distant, where it passes into a tank a few feet above the surface of the ground. The ordinary daily amount of sewage is about 1¼ million gallons. This is estimated to be about 100 gallons per head from each of the 10,000 inhabitants, the remainder being the wastes from the shops. The pumps have a daily capacity of 5,000,000 gallons, so that, although they run only a part of the time, no sewage remains in the cistern longer than three hours.

From the tank on the farm the sewage is distributed through underground vitrified pipe to hydrants and hose. During the winter months not much sewage is allowed to flow over the farm proper, most of it being run into prepared reservoirs several acres in extent and allowed to soak away as in intermittent downward filtration.

The land is drained with tile placed five feet under ground and about forty feet apart. There are 140 acres in the farm, which the Pullman authorities estimate to be sufficient for a population of 14,000, giving one acre to 100 persons. The principal crops raised are cabbage and celery. No trouble is experienced from noxious odors, which indeed is the verdict wherever this system has been used. The land on the farm is deteriorating, although a large amount of outside fertilizer has been used. At first thought this seems strange that a few thousand dollars worth of fertilizer is needed on the farm. The sewage, however, is very dilute, as the large amount per inhabitant would indicate. Besides, it is lacking in some of the essentials of a fertilizer. A soil which is soaked with water most of the time must lose some of its essential qualities. It is probable, too, that the acreage, considering the soil which is rather heavy, is not sufficient. Considering the investment in the farm, and the cost of maintenance, operation and pumping, the disposal of sewage on this model farm is very expensive.

INTERMITTENT DOWNWARD FILTRATION.

In intermittent downward filtration no attempt is made to cultivate the land. The sewage is poured on a specially prepared area for say two days, then turned to another such area. For a soil having considerable sand and gravel, four such areas will be enough, the six days of rest being sufficient to allow the ground to dry after the water has filtered through. For such soil one acre to 500 persons is considered sufficient. For heavier soils larger areas will be necessary and more time will be required between applications. The drainage should be such that the water will filter through a depth of from six to ten feet, and unless there is a perfect natural drainage the land should be thoroughly tiled.

An essential to the success of this method is that the several areas have sufficient time to dry out and recuperate, to become filled with air and to oxidize all solid matter left in the soil. Generally, especially in gravel soil, the effluent will contain a trace of the sewage, though not enough to contaminate wells, and never enough to cause a nuisance in a stream.

The only expense of operation, aside from the pumping when the location of the land makes that necessary, is to turn the gates once in two days so that a different area may be used, and to harrow the land occasionally. The cost of preparing the land is slight, especially if it is nearly level in the first place. The only separation between the areas is a slight bank of earth a foot or two high. The sewage will never stand over the ground to a depth of over four inches. The resulting odor from the sewage is very slight and the atmosphere about it is not injurious to health. For our smaller cities where sewage cannot be poured into streams, it is as cheap and as effective a method of disposing of sewage as can be found.

Aside from the construction of works for sewage disposal, their economical maintenance will require either the separate system of sewerage, or a modification of the ordinary combined system, since the handling of the storm water at the works will give only increased expense.

The decision of the proper system, and its designing and construction will give employment to many sanitary engineers in the near future.

PAVEMENTS.

By Geo. F. Wightman, of Peoria.

The first and most important requisite for a good pavement is a solid foundation. Without this it is impossible to maintain a smooth surface, whether paved with granite-blocks, macadam, ashlar, cedar-blocks, cobble stones, gravel, asphalt or bricks. Next in importance is durability, smoothness of surface, and sure footing for horses. In addition to these requirements, a roadway should be constructed of such material and in such a manner as to overcome any tendency to slipperiness; without joints large enough to encourage the growth of weeds or the accumulation of filth; to be least affected by heat and cold; to be easily kept free from dust and consequently free from mud; and withal that the cost will come within the possibility of the smaller cities and larger suburban towns. In my judgment, these requirements are most nearly met where brick of suitable size and hardness are used in paving a street.

Wooden pavements have had their day and are fast becoming things of the past. The strongest argument in their favor is that while new they are pleasant to ride upon. They are incapable of repair and are very short-lived. When a wooden pavement begins to fail, it becomes odious to the sight and decidedly injurious to health.

Stone pavements are economical in point of cost for repairs, but when the injury and ruin resulting to horses constantly traveling over them is considered, they must be rejected as simply inhuman. Horses are wrecked and carriages and wagons are worn out on stone pavements before they have attained an age when the first symptom of feebleness or decay should manifest itself. Viewed in this light the cost of stone pavements is incalculable.

Another objectionable feature of the stone pavement is found in its uncleanness. Of all pavements it is the most disagreeable to ride upon.

The granite pavements are open to the above objections and many more. They have crevices filled with gravel which also serve for footholds. And under heavy traffic the edges of the blocks spall off, enlarging these crevices, creating an irregular surface rendering the pavement as rough to ride upon and as destructive to horses and vehicles as a cobble stone pavement.

Brick pavements have been shown to possess all the good qualities of the best pavements and no objectionable qualities. Brick pavements have attained such a degree of perfection that I feel warranted in pronouncing them the best pavements now in use; and my experience leads me to add that the enduring qualities of a brick pavement are excelled only by granite, and are fully equal to that of Medina stone. A brick pavement properly made with pressed paving brick, such as are used in the city of Peoria, with the joints filled with distilled tar, will be as smooth as asphalt, as noiseless as a new wooden pavement, and will never become muddy.

The brick paving blocks used in the Peoria pavements are of the following dimensions: Four inches thick, twelve inches long and five inches deep. These are laid in a bed of gravel five inches in thickness thoroughly consolidated. The joints are filled in with coarse sharp sand. The blocks being hand-pressed,are uniform in size. The upper edges are slightly champered, thereby furnishing the most perfect footing for horses. Franklin street in the city of Peoria, which has been paved about two years, is one of the public thoroughfares and is subjected to very heavy traffic. As yet it shows no sign of wear and is as smooth as any asphalt pavement.

There is no pavement in the state that presents a finer appearance than this one.

After many years of experience in municipal work I am willing to put myself on record, by saying, that for the same amount of money there is no better pavement known to the engineering fraternity than a properly constructed brick pavement. It is simple in its construction; it is easily, quickly and cheaply repaired. It is the

smoothest, most durable and economical pavement, and from a sanitary standpoint is without an objection.

In the selection of material for the manufacture of brick for paving purposes the properties of hardness and toughness are indispensable; only such material should be used as will burn to the consistency of flint and yet retain all its powers of toughness. With such brick as I have described, a pavement can be made having no inequalities of surface, and presenting no resistance to heavy loads.

We have in the brick pavement the combined good qualities of the granite-block, the macadam, the ashlar, the cedar-block, the cobble stone, the gravel and the asphalt without a single one of their objectionable features, and this too at a cost only a trifle in advance of the cheapest pavement named.

In the city of the Hague, Rotterdam and other large cities of Holland, brick, for more than a century, has been the only finished material used for paving. The streets of their principal cities are subjected to as heavy traffic as the streets of the largest cities in Europe. During the last summer a friend of mine visited the "city of the Hague," a city of 150,000 inhabitants. and made a careful examination of the brick pavement on one of the principal streets. It was laid more than twenty-five years ago and was in perfect condition, giving but little evidence of wear during all these years.

It only remains for the brick manufacturers to produce the proper material in order to create a universal demand for their wares. Some have accomplished this result, and their success is stimulating others in their efforts to secure the same end. Wonderful progress hss been accomplished in the manufacture of clay during the decade just past. Basing our expectation upon past results, we are warranted in hoping for such success in the future as will secure to us good, durable and cheap pavements.

DISCUSSION.

Mr. Burnham.—I must say that I endorse that paper. I have seen brick used in Chicago,Decatur and other cities, and think it very good. It is not so noiseless as wood.

Mr. Wright.—What is the way of preparing the foundation?

Mr Wightman.— We make a foundation of five inches of gravel. First the earth is rolled with a heavy roller and then the gravel rolled after being placed in position. Then is laid some sand and then the brick. A paver laid two yards a minute. Lay it on the same foundation as you do granite and I think it quite as good.

Mr. A. C. Braucher.—What is the average cost?

Mr. Wightman.—All less than $1.70 per square yard including court costs. Contract price, $1. 70.

Mr. Bell.—Is it a fact that you have plenty of gravel at Peoria?

Mr. Wightman.—We pay from 75 cents to 90 cents per yard for gravel on the streets; sand about the same price.

[See in connection with this the cost, durability and specification of brick pavements in A. H. Bell's article on Bloomington.]

ELECTRIC LIGHTING FOR SMALL CITIES.

By JAMES H. GARRETT, of Chicago.

There are two classes of electric lighting, viz: Incandescent and Arc.

The *incandescent* lamp depends for its light-giving properties upon a carbon conductor heated to whiteness by an electric current. The carbon is protected from oxidation by being in an exhausted glass receptacle. The lamp has been handicapped for street lighting by the great size of wire needed to carry the current any considerable distance, an objection that has been entirely overcome in a practical manner by several manufacturers of electric lighting machinery. This light is especially adapted to very small cities that do not wish the expense of more brilliant arc lamps. They are also useful, in conjunction with systems of arc lighting, in dark but small corners where a powerful arc lamp could hardly be afforded.

These lamps are always placed on posts on the curb line, and are covered by a unique hood, which also acts as a reflector to disperse the light in proper directions. For a general distribution and for neat and artistic affect, both indoors and out, the incandescent lamp has no rival.

The *arc* lamp depends for light-giving properties upon the light emitted by an electric current passing through a small space between two carbon electrodes and also upon the incandescence of these electrodes heated by the arc. It may be added the high efficiency of the arc lamp, viz, nine hundred to one thousand actual candle-power per horse-power, is due to the intense heat to which these carbon points are subjected. The great brilliancy and high efficiency of the arc lamp makes it especially adapted to street lighting.

Height and Position.—In suspending arc lamps much judgment should be used, both as to the position and height. Authorities differ as to the proper height of an arc lamp. Some advocate as low as fifteen feet, others place them one hundred and fifty. In the latter, the tower system, usually a cluster of from three to six lamps are placed in a tower. One of these clusters disperses a soft mellow light over a considerable area. They light alleys and yards as well as streets and greatly aid the police. The objections are the waste light and the necessity of clustering the lamps together. The other system suspends the lamps singly on low supports. The height should depend upon the distance between lamps—the farther apart the higher. I may mention that in the Chicago system on Madison street, where the distance varies from one hundred to two hundred

feet, they are placed on supports eighteen feet from the pavement. When from eight hundred to one thousand feet apart, they should be at least thirty-five feet high, and when suspended above the street a greater height should be insisted on than when on the curb lines on account of the dazzling effect on persons driving. Placing lamps on posts on the curb line is quite practical where the lamps are close together—say two on each block—so that they may be placed on low supports, but otherwise they should be placed at the intersection of the streets, either by suspending them from a wire stretched from poles set an diagonally opposite intersections of curb lines, or preferably by suspending from a mast arm. The latter method is quite as cheap, much better and more durable, and by elevating these arms to an angle of thirty-five degrees with the horizon, we can raise the lamp ten or twelve feet higher than otherwise.

Lamps.—No lamps should be used that need a lamp board or other unprotected device to decay, rust or burn. Those protected by an ungainly and unsightly umbrella-like hood that will tear the lamp from its fastenings in the first wind storm, should also be avoided. The lamps should have no extremely delicate parts and must be simple and easily adjusted.

The question is sometimes asked about the advisability of using nominal 1,000 (actual about 400) candle-power lamps. With these lamps there is a very slight saving in first cost of dynamo, engine and boiler, also a small saving in coal over nominal 2,000 candle-power lamps. The first cost of lamps and lines are the same, as also are the repairs, carbon and attendance, while the amount of light is very much less. Taking this into consideration, it is easily seen that the "half arc" lamp is an economical make-shift.

The Line.—The line should be erected in a substantial manner. The wire outside of the station should touch nothing but glass insulators, placed right end up, and the lamps. Insulated wire is useful in protecting line men from daylight circuits while at work on the poles and to protect the line from telephone, and other wires, which may accidentally be crossed with it. A line, however well insulated the wire may be, should be erected with the same care that would be used with bare wire.

Dynamos.—A dynamo is a machine to change force from one form to another, to change mechanical to electrical energy. The one that does this with the least loss, requires the minimum repairs and attendance is commercially the most efficient. The automatic regulation of dynamos is not to be insisted upon when running a circuit of differential lamps. This is especially the case on street lighting circuits, where the load is practically constant. The appliances require a certain amount of attention, must be adjusted with considerable skill, and unless in competent hands are sources of endless trouble, and the care that these devices require if directed to hand regulation will keep the current on any street circuit of differential lamps practically constant.

Power.—None but the steadiest and most reliable should be used, whether steam or water. The choice of engines should be governed by local circumstances, such as price of coal, amount of room, etc. Where fuel is cheap, good results have been obtained by throttling engines. An almost constant speed must be insisted upon, for as the current varies directly as the speed, not only minute by minute, but throughout each revolution, we cannot expect good results where the motion is pulsating or wavering.

Position of Station.—Where steam is used, the convenience to fuel and water must be taken into consideration, although the interest on the additional cost of land on a railroad may pay for the coal hauling for the proposed plant. It has been the universal history of electric plants to far out-grow the original designs, and for this reason enough land should be purchased to allow for growth.

Finally the points to be kept constantly in view in the entire installation are, Reliability; Durability; Simplicity; Economy in operation; First cost.

You see the order is reversed from what they have been written by others. The first three are so intimately connected that they are almost synonymous, and the fourth depends greatly upon them. When we take into consideration the amount of money required to operate a plant throughout its life in comparison with the first cost, it is readily seen why that should come last on the list. It should be remembered that these last remarks apply to the entire installation from the boiler room to the farthest lamp on the line, and the more we invest intelligently, the less will be required for repairs, and the liability for annoying shut-downs will be decreased. Nor should we stop here; after the plant is properly installed it must be handled with intelligent care. We cannot expect any system to give satisfaction when handled by inexperienced men, any more than we would expect a fine engine to work smoothly when run by one unacquainted with machinery. Yet let me say that the greater part of our troubles are mechanical rather than electrical, and any man who is really capable of handling an engine, can soon master a dynamo.

So far I have shunned the financial side of the question. This depends on so many local circumstances that each case needs to be canvassed by itself. Where a small city owns the water-works, an electric plant may be run in connection much cheaper than it could be operated separately, and if there is no electric plant in the town, commercial lighting could be added. The latter may be made to partly defray the expense for city lighting. If there is a plant in the town, light can be usually contracted for at a figure so low that a city plant would not pay, if we make any calculation for depreciation of the property.

THE CONSTRUCTION AND MAINTENANCE OF LEVEES.

By E. J. CHAMBERLAIN, of Pittsfield.

In this article I shall not attempt to give any technical or theoetical formulæ or ideas but, instead, a few suggestions learned from a combined study of authorities and a practice of a few years upon the levee of perhaps the largest drainage district in the middle states, known as the Sny Island Levee. And this is intended more as an indirect aid or suggestion for thought to those who may but occasionally be called upon to build a levee than as authority for the specialist.

Location.—Location of the levee should be governed by, first, the amount of land to be reclaimed from the flood; second, the expense of construction; and third, the probabilities of permanency with little or no expense for repairs. To build upon the bank of the stream furnishing the flood waters would comply with the first requisite, and also the second provided the course of the stream be straight or composed of long and gentle curves, since the banks of overflowed streams are invariably higher than the adjacent lands and consequently require less height of levee to reach the desired plane of protection.

To follow the banks of a tortuous stream may not reclaim a sufficient amount of additional land to justify the increased expense over and above a straighter alignment across narrow necks of land. That can be decided only by actual surveys and estimates of costs.

Under the third item may be considered: (a) Levees upon those streams that are dry portions of the year. For such, a good outlet is most desirable for permanency. Without that it matters not how good the levees may be made they will require additional height each year, the amount of which will depend upon the amount of the drift, silt, etc., that is deposited near the outlet, filling the channel in a few years above the original levee banks and causing an outlet over the levees much up stream from the original outlet. Our county has many such, all but one engineered by the land owners and protecting only those upon the side of the creek having the highest levee.

(b) For those streams having a continuous supply of water such as the Mississippi—where my experience has principally been —the levee should be located far enough from the bank to leave room for obtaining all material for construction and maintenance from the river side of the levee. Let me emphasize that by saying, let the general rule be, never remove material from the land

side of the levee except for a shallow seep ditch thirty to one hundred feet from the foot of the levee slope.

To prevent its being undermined by the river the levee should be placed a greater distance from the concave banks of the stream than elsewhere, for those points wear away faster because of receiving the full force of the oblique current. When the river bank is composed of tenacious material the distance of the levee from the stream may be much less than when of quicksand or other easily moved material.

The grade line of the levee should be established from the actual plane of highest known waters. That taken before construction of levee may show a uniform fall, but when the waters are confined between levees, the high-water plane will vary much from a uniform fall, so that an additional height of from six to twenty-four inches at and above sharp curves following long tangents of the stream will be necessary; for at such points the high-water plane may be level for some miles above and regain its normal plane in a short distance below the curve. The true grade can be obtained only by notes of high water after the levee is constructed.

An ideal grade line would be three to five feet above the highest known water, but a comparison of costs and benefits will generally justify placing the grade at or but one or two feet above the highest known water.

The cross-section of the levee should be governed by the height of grade above high-water plane; the quality of the material; its exposure to erosion; and the length of time exposed to water. For small streams with high grade line where the material is tenacious and the longest period is but a few days, a three feet crown with slopes of one and one-half feet base to one vertical may be used, varying, to meet the other extreme of conditions viz., a low grade, easily moved material, such as quicksand or a sandy loam, exposed to the action of waves brought by a long reach or exposure to winds and liable to such exposure from one to three months at a time when the following should be used, a cross section of five or six feet base to one vertical on the river side and extending as high as the average high water of long duration, thence changing to a three feet base to one vertical to the top. A crown of five to eight feet, and a land slope of four base to one vertical extending as high as the gentle slope on the outside, thence changing to a two feet base to one vertical to the top is probably the most economical where the material at hand is to be used. Riprap for exposed places is better.

Were it not for the great expense gentle slopes carried to the top would be much better. If the river slopes of the levee are gentle, the waves will expend their energy by rolling up the slope with but little friction; but if the force of the waves or oblique current be suddenly checked by a steep bank the erosion will be rapid. The slope upon the land side should be so gentle that when thoroughly saturated there will be no sloughing or running away of the mater-

ial. From the above we may say that no arbitrary rule for the cross-section of the levee bank can be adopted, but that a study of the natural slopes formed of the different materials and under the varying conditions above noted is necessary to decide each individual portion of the levee.

Experience here has demonstrated that where the levee was not composed principally of quicksand but of such material as is usually found in our alluvial lands (coarse river sand makes a good levee after a time for infiltration to stop seepage) this cross section, viz., a four feet base to one vertical for the river slope and a two feet base one vertical on land side, with a five feet crown, is sufficient. Raising a defective grade line with a small ridge of loose dirt, sand-bags or boards held on edge by stakes driven each side, and dirt enough behind to stop cracks, proved sufficient, in May, 1888, to hold the river until it was high enough to have run over about five miles of the original levee bank, the water surface being from eight to seventeen feet higher than the lands. It was exciting and sad to see the hundreds of men engaged day and night in the above work—the last day or two working against all hope—to save what to many was, "their little all" but in the aggregate was about fifty thousand acres of good crops, with as much more of pasture, prairie, etc.

Most of the crevasses prior to this year, (none since 1881) have been caused by the cutting away of the substratum of quicksand underneath the levee proper. The foundation removed, the levee sinks sufficiently for the water to run over the top, when it is soon swept away. This levee has had two such well authenticated cases. I believe such never would have occurred had the loam covering the quicksand never been removed from the land side leaving deep pits for the quicksand to flow into. It does flow, when thoroughly wet, nearly as freely as water.

With the location and form of cross-section decided, the next important item is the securing a good union of the new bank with the ground surface, leaving no seam to lead the water under the levee. This can be accomplished only by clearing the ground of all perishable material and digging a ditch, generally about four feet wide and four feet deep, along or near the center line. The object of the ditch is, first, to cut all logs, roots, etc., which if left to decay leave holes to lead water under the levee; and, second, when filled anew to leave no seam or joint. The ground for new levees or additions to old works should have the entire surface to be covered plowed—not as one would plow for planting with the furrows about two feet apart. Care should be taken to have all material put in the embankment free from perishable matter.

If the foregoing suggestions have been faithfully complied with during construction, the expense of maintenance will be reduced to a minimum. The principal call for repairs will be from erosion from rainfall, as well as flood waters, and from travel on the top.

The travel should be forbidden during wet periods. Some travel is beneficial for the purpose of impactment and also to keep burrowing animals from nesting near the top. Many a muskrat den have I found by the horse breaking through the crust above it.

To the end that a careful watch may be kept during an approaching flood the levee bank should be kept free from brush and timber. In this latitude I know of nothing better than a blue grass sod to preserve a bank.

Those wishing more detailed information will find good reading in Hewson on Levees, E. L .Corthell in Johnson's encyclopœdia, The Mississippi River Commission Reports of 1875, 1879, and 1881 to 1884 inclusive. Embanking Lands from the Sea, by John Wiggins, The Drainage of Districts and Lands, by Drysdale Dempsey.

RAILROAD ACCIDENTS; THEIR CAUSE AND PREVENTION.

By S. F. BALCOM, of Champaign.

In all walks in life accidents are constantly occurring; and it is hard to say which path is beset with the fewest dangers. Those that lie in the path of the traveler are uppermost in the mind of the people; not because the liability to injury is greater than is met with in the ordinary routine of life, for statistics show it is not, but because the intervals between railroad disasters are never long, and some are so appalling that year after year passes and still they are not forgotten.

No explanations will excuse railroad accidents, for they are results of the same old causes, repeating themselves over and over. Some one is always at fault, and investigation always shows that the trouble might have been avoided. However, explanations are always demanded, and the causes are carefully compared and weighed. The busy public takes time to do this; but having linked the chain of circumstances together, the matter is dropped, with an idea that things are not as they ought to be but with no knowledge of how they can be corrected.

Some, perhaps, ask why laws are not made to cover these cases. A reply is seldom received, for it is known that all railroads have regulations in force, intended to prevent accidents; and if these rules and regulations fail after years of trial and adjustment by men whose everyday work makes them thoroughly acquainted with all the details that are affected by the rules, how can it be expected that state laws will better answer the purpose?

The constant repetition of accidents shows that the provisions made to prevent them are not sufficient; or that the regulations in force are not carried out; or that accidents are bound to occur.

While it is true that there is always a sufficient cause for every accident, still, an imperfection almost unnoticeable, or a cause almost inconceivable, may make trouble, and sometimes most serious trouble: while, at another time, a very serious defect may not cause the least trouble. A case comes to mind of a passenger train, under full headway, being blown from the track—lifted so completely that the track was not injured in the least. Another, where a passenger train left the track on a sharp curve, the track remaining in good condition; the only conceivable cause being a spike, or some obstruction, on the outer rail, causing the engine to jump the track and take the cars with it. On the other hand, a freight train broke in two recently, while pulling into the yard at its destination, at a slow speed; after having passed over portions of road where, if the coupling pin had broken, a serious accident might have occurred. Cars have been found in the Cairo yard, coupled with a small bolt instead of a coupling pin, which had come up the steep incline from the boat transfer without causing trouble. Another instance came up recently, where one of the wheels in an engine truck broke, derailing the truck, passing on over the track, breaking bolts, cutting heads off spikes, or crushing them into the ties, and leaving the track very insecure for a quarter of a mile. At one point, on a trestle, it broke all the bolts in a rail joint, broke the joint tie, which was a cross-grained sawed tie, and broke the opposite rail across from the joint, and still not a car was derailed. How could it be expected that a defect like this—a broken tie on a trestle, supporting a rail joint with the fastenings broken, the opposite rail also broken, over the broken tie—should allow a train to pass over without causing a wreck?

Instance after instance, could be recited, to show that the results are not in keeping with the apparent causes; and that it is impossible to prevent all accidents. How a better state of things can be produced, is the subject for consideration, and leads into a broad field.

It is evident that of the vast net-work of railroads in our country the larger portion are branch lines, or second-class roads; and that many of them have to be operated with the least possible outlay, in order that they may be operated at all. It is not to be expected that secondary lines will be as substantially built as the main lines; and while wooden or pile trestles, for instance, can be allowed on roads running only a few trains daily, these trains being light and run at a slow speed, it would not be justifiable to make use of such structures on an important line, running many fast passenger trains and through freight trains at a high speed, and over which heavy engines and many heavy loads pass. That there is, and must be, a dif-

ferent standard of construction and equipment on different classes of roads, is certainly the case. The fact that railroads are fast being gathered into systems, with main or trunk lines and auxiliary branches, is a matter of considerable promise; for, if honestly operated, a far better condition of roadway and equipment can be maintained than would be possible if each line was operated separately.

Methods of work and standards of construction for the trunk line will be introduced on branch lines, as fast as the business of those lines will justify. In this way, a standard of excellence is established and a progressive movement started—the two things most to be desired.

The best results are obtained where those in charge of railroads are allowed to incur the expense necessary to maintain all parts of the property in safe condition and to employ the most proficient men to be had in the various lines of work. Retrenchments necessary in order that a certain dividend may be realized, often sadly interfere with the accomplishment of satisfactory results; but with an allowance sufficient to accomplish all that is demanded for the sake of safety, a method of construction and maintenance will be possible in which not simply the present result, at the least possible cost, will be considered, but also the matter of endurance, future expense and safety, will receive due attention.

Railroad accidents may be divided into three classes: those caused by defects in the roadway; those resulting from defective equipment, and those brought on by inefficient service.

Of the first class, the most serious accidents are probably connected with defective bridges.

The faults of all of the old styles of iron bridges have been pointed out over and over. Although an improvement on the earlier wooden bridges, they were not intended for the present heavy engines and loads. The factor of safety that was supposed to have been a known quantity is found to be very indefinite. All roads must know the weakness of their old bridges, and any amount of watching and care can not make them absolutely safe.

The timber structures are probably responsible for the most trouble; as they are subject to damage by fire and by water, as well as to rapid decay. They should be closely watched by trackmen and roadmasters; although they may belong, properly, to a bridge department. Mowing and burning weeds around wooden structures only partially protects them from fires. The only safe way is to keep the ground bare next to the timber and under the structures at all times, or to apply a coating of cinders sufficiently thick to prevent weeds growing through. Even this will not make them proof against fire; for as many, or more, structures burn from fire dropped on the stringers from engines as from grass or rubbish burning under them. I have known several such fires since the Chatsworth disaster, but none caused by grass taking fire. A stringer may be decayed on top, so as to be a regular tinder box; and still be sound be-

low and amply strong. Fire-proof paint or coating would not protect timber in such a condition. A strip of sheet iron placed on top of stringers and under the ties would be the best protection.

Cattle guards are subject to the same danger from fire and should be equally well protected. They are also, when constructed, as "open guards," liable to cause trouble from another source. Should a derailed car pass over an open guard, where rails are spiked lengthwise on a stringer, without the use of ties, the truck would centainly enter the pit, and a wreck would follow. All cattle guards should have good sound ties which should be securely fastened in place, so that, if necessary, they would stand the blows given by derailed truck wheels.

Water-courses are constantly shifting their position; and if allowed to leave the proper channel, a washout may result at any high stage of water. Earth embankments, breakwaters, or riprap protection will remedy nearly all such cases. There are sometimes places where, after heavy rains, the water floods the track; but at places where there is little or no danger from washouts the trouble is often considered more easily borne than remedied.

Broken rails are the source of many accidents; and this danger is one of the hardest to provide against. Of 90 steel rails that broke in main track on our division during the past year, 80 broke within a foot of the end of the bar, showing the weak place to be at that point. The precautions that should be taken, are to have as strong joint fastenings as can be procured; the joint and shoulder ties should be sound and full-spiked to hold the rail as firmly as possible in case it does break; and good ballast is needed to secure properly-tamped ties, thus preventing joints, in a great measure from getting low.

Where there is trouble from rails creeping, a strain is brought on the joint fastenings, and they often break; the iron then runs, leaving an open joint which is very dangerous. I have known fish-plates to break under these circumstances, and leave an opening of 14 inches. The creeping motion is very strong in some places, and on some of the mountain divisions of the Colorado roads, I have been told, the track goes down grade 6 feet or more in a year. It is particularly noticeable at public crossings, where the crossing plank have to be moved. On most roads creeping can be prevented by securing every rail joint to the tie; this requires the ties to withstand the pressure of a single rail length only, when, if the joints are fastened only occasionally, as is often the case, the pressure is great enough to throw the tie bearing the strain out of place. On trestles, where rail-joints were spiked in slots and the tie drift-bolted to stringer, I have known the pressure to tip the bents, and sometimes split the ties.

Another weak point connected with the maintenance of rails is that the elevated rail on sharp curvesk eeps working over, the base of rail on outside cutting into the tie until the ties are rendered unsafe,

while the timber is still sound; the inside base of the rail, at the same time, cutting the spikes until there is danger from the rail tipping over. "Servis Plates" are made, which, if used, will prevent the rail tipping over by keeping it from cutting into the ties. One danger from frogs, guard rails and rails in crossings, is that people get their feet caught in them. Blocking has sometimes been used to overcome this danger, but it soon decays or becomes loose and is itself a source of danger.

The accidents occurring at switches and frogs are numerous, and are frequently the result of a split switch having previously been run through by an engine or cars, damaging the switch. Some roads use a connection rod with a spring attachment, but these are not safe at all times; for should snow, or some obstruction, clog the switch rail, the lever could still be sprung to place and fastened, leaving the switch rails in a dangerous position. Connection rods can be made, however, with a coil spring compressible by passing wheels, but so stiff that a person in handling a switch could not spring it.

Dangers to be classed with those of roadway, although having very little connection with it, are that of loaded teams crossing the track and of stock running at large on public highways, either of which, if struck, might derail the train. These are things over which the railroad company has no control, and the only thing that can be done, is to keep the wagon road next the track and over the rails in such a condition that teams will not get stuck and delayed while passing over the track.

Quite similar to the case last mentioned, is that of stock being struck on the track between stations, and not on the public highway, only in this case the trouble can be traced to defective fences, or farm gates being left open. The law requiring railroads to fence their so-called Right of Way, is a police regulation, made to protect the traveling public from accidents that are liable to happen when stock is run over. Railroads are held liable for damages, as accidents of this kind are held to be the result of a lack in complying with the law; but it is impossible for railroad companies to keep gates at farm crossings closed, and the land owners should be made responsible by law for all damages sustained on account of such gates being left open or insecurely fastened.

Passing to the second class of accidents, those connected with the rolling stock, the item that first presents itself is that which has received so much attention in the last few years, viz: the danger in heating cars by wood or coal fires and in lighting them with oil lamps. The remedy, that of heating by steam, has been found and will probably, in a few years, come into general use, as will also electricity for lighting. Vestibuled cars are a new feature, and point to a method of construction that will, to a great extent, prevent the telescoping of cars in wrecks; for the frame work of cars at the ends can be built with a view to withstanding greater pressure. Air

brakes have proved themselves very valuable appliances, but at times have failed to work properly.

Defective engines are sometimes responsible for accidents. In the case already mentioned, where a wheel in the engine truck broke, the base of the wheel had a circle of flaws in the centre of the tread that were plainly visible on each piece of the broken wheel; and there were a large number of the pieces.

We have had some accidents from engine and car trucks not being properly trammed; one wheel crowded the rail until the flange became worn half off, and very sharp; the other wheel not showing any sign of wear on the flange. Such trucks are very liable to catch the point of a switchrail or frog. Defective trucks on cars are constantly causing trouble. Brake beams and shoes get down and catch under the wheels, derailing the car; axles and wheels break, causing wrecks. These defects, like the defective wooden structures in the track, require constant watching from all employes, as well as from those who are directly in charge of them.

The third class of accidents, covers those that are the hardest to prevent. A mistake on the part of almost any employe engaged in the work of maintenance of road or equipment, and particularly of those in the operation of the road, brings in an element of danger, which, though small, may result in a serious disaster. Still, work is done, day after day, without a thought of the responsibility that attends it. From the trackman who fails to find the broken rail, to the train dispatcher who gives a "lap order," the same fault almost always exists: viz, the lack of close application.

Trackmen may fail to examine their track after heavy rains, or fail to report a bad trestle because recently examined by the bridge inspector, may take up a rail after sending out a flag, but fail to use torpedoes, or may not send the flag a sufficient distance.

Bridge inspectors may think a wooden structure will last another year, or until men are working in that vicinity. Bridge men may partly spike the ties on a trestle, expecting section men to complete it. Car repairers may neglect to repair a car, because it is a foreign car and will soon pass over to some other road. Trainmen may leave a switch open, expecting to pass through again soon, but a wild train reaches there first. Engineers will follow in sight of another train, when the rule is to keep 10 minutes behind. Telegraph operators may fail to put out their signal, to hold a train for orders, or may release a train that he has orders to hold. These are many other slips that are made all because of a lack of close application.

The best service is obtained by carefully selecting men to do the work. There should be different grades, and promotion should be the reward for careful and thorough work.

It often happens that trainmen, in order to get over the road quickly, or to make up lost time, will take risks that are known to be wrong. They often claim they have to do so, in order to get over

the road in any kind of time. The fact that violations of this kind are not noticed unless they result in a wreck, leads men to think that while the rules should be observed when there is known to be danger, they are impracticable for constant application; and knowing if bad results follow they will be met with the severest punishment, it becomes to them a matter of luck whether they get into difficulty or not. Under this state of things, constantly neglecting small matters of precaution, men become familiar with danger, and a condition of things the very opposite of what should be desired gradually comes about. Every time a regulation is violated, the acute sense of responsibility is blunted, when for the sake of all concerned it should be constantly growing stronger.

To this end, all rules should tend; they certainly should be made applicable at all times, and the fact impressed that it is as serious a matter to violate a rule at one time as at another.

Railroad management is a complicated problem; it covers a larger field than any other industry, and considering the dangers and difficulties to be overcome, is entitled to greater commendation. That railroads lay hold of improvements as fast as introduced, shows that they recognize the importance of having everything in the best possible working order.

Failures point out the way for improvement; and if their voice is listened to and the lesson they teach is rightly obeyed, a progressive state of systematic improvement in all departments will exist. With experience as a guide and a willing disposition to improve, what is now known to be an unsatisfactory state of things, may be changed into one that will be highly commendable; and we trust this will be the case, for nowhere are the best results more sought after than in railroad management; and never was there a people better able to appreciate the accomplishment of such a result or more ready to commend it than the American Public.

SUPPLEMENTARY PAPER ON NICHOLS HOLLOW CULVERT.

By EDWIN A. HILL, of Cincinnati, O.

My paper of last year on the *Nichols Hollow Culvert* was reprinted in The Railway Age, and not long afterwards one of the engineers of the Rock Island Road, through the columns of that journal, asked some questions concerning the work, which, at the editor's request, I answered in some letters to that journal. What I have to say now as supplementary to my last year's paper, though suggested by those letters, is not altogether a repetition of them, and I presume that data as to how the structure has thus far behaved will be of interest considering that in some features it was somewhat of an experiment.

The questions raised were briefly these: First, were the foundations carried deep enough to resist the action of frost in heaving, and of water in undermining the structure. Second, does not the height of surcharge, coupled with the dimensions of the structure, indicate excessive pressure on the foundations. Third, how has the structure resisted the action of floods and frosts? Does the invert show any signs of failure by humping up in the middle; and is the alignment still perfect through the arch?

The structure you will remember was a semicircular arch culvert. Span 6 feet. Side walls 3 feet high, with an inverted arch for a pavement laid with cut stone over a stratum of quicksand for about 40 feet in from the lower portal of the structure and laid for the balance of its length, where the quicksand was less formidable, in rubble broken with stone-hammers to an approximate voussoir shape and grouted with Alsen Portland Cement mortar. Total length from out to out of wing walls 218½ feet; height of track above invert 67 feet; foundations of side walls carried about 2 feet below the upper surface of invert, except as hereafter described.

The first question raised was whether this 2 feet depth of foundation was sufficient under the circumstances to resist the action of frost and the undermining of the water. In the given locality our roadmaster considered 3 feet the limit of frost. I figured on 4, though having less experience than he in the given locality. It is probably true that there two feet of depth would give for a retaining wall or house a foundation liable to feel the effects of frost, but in a culvert over 200 feet long and covered up with 60 feet of embankment, frost, except near the portals, could affect the foundations only by entering the bore of the culvert and first penetrating

through about 2 feet of solid stone invert as well as the layer of ice which will form on the invert or pavement to the depth of several inches. Now in winter, as is well known, it will be much warmer within such a culvert than without, and the layer of ice on the invert being a non-conductor, we have at least two reasons why the frost will not penetrate as deeply. True, we may not be able to state in mathematical terms of x and y by how much we may safely reduce the depth of foundations, yet practically I believe that in a long culvert, placed deep below the surface, this is too considerable an item to be entirely disregarded. Here evidently we have a reason for a reduction of the depth of the foundations in the interior of a long culvert provided that in so doing we do not expose them to the undermining action of water.

Of course, until the paving is washed away no such undermining can occur, so that the better the character of the paving, or the less treacherous the character of the stream, the safer we shall feel about making such reduction in foundation depth, and while in short culverts the saving is of little importance, yet as the length increases the saving becomes considerable. With a well-constructed invert laid in Portland cement we have about as strong a substitute for paving as can be had and one I think cheaper than any other if this reduction in foundation depth is duly considered. There is little or no chance of its being carried away, so that undermining, unless started at one of the portals, could hardly occur at all. Here, again, we find another reason for an extra depth of foundation at the portals, to-wit: the danger from undermining; and in the original plans, having both floods and frost in mind, I carried down the foundations an extra foot, or three feet below the top of the invert for a distance of about 6 feet into the culvert. Mr. Diddle (our roadmaster) and myself discussed the question of whether frost would penetrate the one foot of masonry and additional foot of concrete, two feet in all, forming the apron on which the wings were started. I considered this an experiment, but he seemed confident that it would not penetrate when reinforced by the thick layers of ice that would at once form upon it. We, therefore, put it in as an experiment and thus far his conclusions seem to be justified by the results.

The culvert has now passed safely through one winter and is well along on a second, and I may say here that the alignment through the arch is absolutely perfect. No signs of settling under pressure of the embankment, which is now completed, appear. The invert stands intact, without any tendency to yield or hump up in the middle, nor has the frost had any apparent effect on the aprons —in short the structure remains unchanged and just as constructed in the summer of 1887.

As far as undermining is concerned this generally begins at the ends of the structure, that is if the pavement has any merit at all. To resist this I am in favor of good deep barriers carried clear across the work at the ends to prevent the water getting under the

side walls. In this case two such barriers were provided for. The original plan called for a solid barrier of masonry carried across the mouth of the culvert 3 feet wide and deep, and likewise a curb of stone 3 feet deep and 1 foot wide carried across the end of the apron. The quicksand forced us to abandon this style of construction at the down-stream end, as described in the previous paper, it being only two feet from top of apron to the layer of quicksand, but at the upper end where no quicksand existed this construction was used, the fact not being mentioned in last year's paper.

I suggested the precaution of paving the bed of the stream for some distance below the down-stream end to prevent the clay from washing away and letting the quicksand out from under the apron, but it was concluded finally to watch the action of the stream to determine whether this were really necessary or not. The result proved the wisdom of the suggestion, and furnishes a good example of the action of a rapid current of water upon a clay stratum overlying a bed of quicksand. Two washouts have thus far occurred, both, however, below the end of the culvert, and neither of them injuring the structure in the least, but proving the necessity of protecting the bed of the brook for a distance sufficient to allow the discharge from the culvert to spread out and so loose its eroding power.

The second of these occurred during the past summer. The storm was the most severe in the history of the locality. The oldest resident, with an experience of forty years, claims that the water never stood higher but once before, and then only about an inch or so. At this time, for an hour or two, the water rose faster than the carrying capacity of the culvert, and dammed up on the upper side until it stood 3 feet above the extrados of the arch. I have been unable to get as accurate observations of the amount of rainfall as I could wish. Six inches of rain fell during 20 hours, as shown by the accumulations in pails and buckets around the neighborhood, and, as is claimed, 5 inches of this fall occurred in from 3 to 5 hours. It had been raining for about 24 hours when the heavy rainfall occurred. The bed of the brook below the structure washed out to a depth of from 2 to 6 feet, over an area of about 18 feet square, but far enough below the apron to avoid undermining it. The culvert itself stood intact. This, I think, shows how great the eroding power of the water was, and also confirms the views above expressed that the best place to spend the money is on the paving and the barriers at the portals rather than in carrying down the foundations to an excessive depth.

The question of whether the stresses on the foundations were excessive or not is a practical line of inquiry, and one which I think deserves more consideration than I can well give it in this paper.

In such cases as this, can we tell what the pressure will be? Are theories and formulæ of any practical value here? I am inclined to answer both yes and no in the same breath. Yes, if we

regard them as giving us limits of pressure which can never be exceeded, and of which a fraction only can ever be realized in practice. No, if used in any other way, as is too apt to be the case.

Some might argue at first, and with a show of reason, that the foundations support the prism of earth directly over them, and hence it is a mere question of how much that prism weighs; but practically no such pressures are ever realized. No mere theory of the pressure of earthwork will exactly apply in practice, for in no two cases are the various conditions alike. With a fill 60 or 70 feet high and a long culvert or pipe, much of the central pressure is carried to and sustained by the ends of the structure, how much it is impossible to say. Theory might perhaps work out a maximum centre pressure that could not be exceeded which would be much less than the pressure or weight of the superincumbent prism of earth, but even then this would be more or less reduced according to the varying conditions.

If we shovel away the earth at the toe of our embankment directly over one of the portals of our culvert we shall have the rest of the bank sliding down from under the rails and ties, showing that only a portion of the total weight of earthwork over the central section of the structure is really sustained by the central foundations. To elaborate a theory as to what this distribution of pressures from the central to the end sections amounts to would be a useless undertaking, for while perfectly dry sand of uniform grain might possibly conform with reasonable closeness thereto, we can predict little or nothing of the varied materials which the engineer uses in actual practice further than the general statement that as the material from its nature and the methods employed in handling it, aided by the effects of time, tends to become compacted and consolidated, the pressure tends to become uniform over the entire base upon which the embankment rests, the mass of earthwork acting more and more like a monolithic pyramid of stone. Suppose now after allowing for all of these indeterminate deductions from the theoretical pressures obtained by calculation we consider the case of the Nichols Hollow Culvert, viz: a culvert with a strong invert to distribute the pressure over the entire foundation, and consider that we are filling with moist clay, not sand, dumped from a trestle and falling about 60 feet. Evidently after filling in this way to a depth of 35 feet we shall be far from approximating to the conditions of fluid pressure, the starting point for so many of the theories relative to pressures in earthwork, and our material will be compacted about as solidly as we ever find it in new work. Now suspend operations for the winter and in the following spring we would probably find, if there were any way to determine it, that the additional material put into the fill would not greatly increase the central pressures on the culvert.

I presume many will recall instances of where a culvert or drain pipe has washed away from under an old and compacted embankment carrying a highway, or it may be a railway, and yet the natural arch

formed by the compacted soil, after the culvert has been partly or wholly taken out, has sufficed to carry the traffic in safety until the damage was discovered and repaired. This will illustrate what I mean when I say that the thorough compacting of the earth in high embankments begun in construction and continued by the processes of nature tends to equalize the pressure over the foundations, and by forming such a natural arch over any pipe or culvert built under the same, tends to relieve it from excessive pressure; and that the maximum stress from the surcharge comes upon the culvert during the process of filling in and grows less from year to year as the embankment becomes more and more solid and moreover falls short of the theoretical pressures by a difference increasing rapidly with the increase of surcharge.

In answering the first two questions raised, I have incidentally answered the third. The structure thus far is a success. It has stood the test of frost and floods, and while time alone can determine whether in so far as it was an experiment it was a successful one I think the results thus far tend at least to increase ones confidence in the following principles of construction, all of which are embodied in the plan of this particular structure, to-wit:

1. The use of an inverted arch in lieu of pavement and especially when quicksand is encountered under the peculiar circumstances of the given case.

2. The use of deep curbs and barriers at the portals coupled with a strong paving and a reasonable reduction in depth of foundations to wing walls in the interior of the structure.

3. Wing walls flared or splayed into the side walls with no angle at the junction to catch drift-wood, etc., thus affording an easy entrance to the water and a correspondingly increased carrying capacity of the culvert.

4. A reasonable use of—rather than a blind adherance to—the various rules and formulæ relative to pressures in earthwork and stresses in masonry under high embankments.

DISCUSSION.

Mr. Balcom—Mr. Hill is right. The ends of culverts is the place to spend money for protection. It could be used more generally. I noticed some barrel culverts on the I. C. road in Southern Illinois where the ends project out without cover. Were they sodded there would be no wash.

Mr. Baker—I object to the office of the invert as to distribution of the pressure over the foundation. The pavement should not support the walls or the weight above.

Mr. Hill—I agree with Mr. Baker in the main. I refer especially to the foundation over quicksands. We were at one end on a

layer of quicksand four feet deep. I would lay the invert so as to prevent the quicksand from coming up in the center. In the upper portion where there was no quicksand we did not use the invert.

Mr. Baker—I misunderstood the conditions. The invert was used to hold the quicksand under and keep the foundations of the side walls intact.

COAL MINING.

By A. C. BRAUCHER, of Lincoln.

It might be said that a coal mine is a coal mine and that a description of one could be taken for the whole; but such is not the case. The plan of working may vary in no small degree, while the equipment may comprise all the best and most desirable machinery or consist merely of a pick, shovel, man, mule and cart. Hence this paper will be confined not to a single mine, but to a short enumeration of the appliances that go to make up the equipment of a well-appointed coal mine.

The operation of a mine may be divided into the following departments: Mining the coal, hauling, and grading; while to make these operations possible we will have to attend to the drainage, ventilation and maintenance of the mine in a proper condition to avoid needless danger to the life and limb of the miner.

The initial power for the operation of the machinery of a coal mine is usually steam, most economically generated in a battery of boilers fitted with grate-bars for the burning of slack or waste coal. The power thus developed is sometimes utilized in the form of compressed air or electricity, for use in the mine where distance is a serious drawback to the use of live steam, both on account of the loss by condensation and the inconvenience caused by the heat. Let us now take up the appliances in the various departments in order:

Mining the Coal.—This head will include the operations from the attack on the coal at the working face until it is loaded into pit-cars ready for hauling. If the coal is free and contains well-defined slips, it may be mined and sheared, after which a few well directed blows from a sledge and wedge will bring the coal down. When the coal does not work freely, powder should be used, care being taken to avoid an overcharge or waste of force by a poorly disposed drill hole. The coal is undermined by means of picks, or mining machines. In the latter case air compressors will be required to furnish the power. Mining machines can be used with safety only in case

of good roof, on account of the space required for setting the machines, which must be unobstructed by props. These machines require two men to operate them and they do the work of ten to thirty miners. It will rarely be economical to blast coal from the solid without mining, as the coal is broken up badly and the danger of blown-out shots is increased.

Hauling the Coal.—The conditions of haulage are so varied that a number of appliances may be used to advantage,—the slope, the plane, the level and the vertical hoist. In hauling on a slope a trip usually consists of a number of pit-cars coupled together and propelled by means of a winding engine. The plane is operated by means of a sheave or drum, the descending loads bringing up the empty cars. The levels may be worked by endless rope, locomotive, electric motors or mules. The vertical hoist is made in cages running in shaft apartments, provided with guides for steadying the motion and safety clutches which act in case of breakage. The engines for shaft hoisting are usually first motion, while for use on slopes second motion engines are preferable.

Grading the Coal.—The coal is taken as it comes from the mines and separated into the different grades for the market, according to the demand and quality of the coal. The greatest degree of perfection in this work is attained in the anthracite regions, where the coal is crushed in massive rolls and then separated into various sizes by passing over a series of meshes in a revolving screen until it finds its way to the proper bin. A uniformity of quality is thus obtained which could be reached in no other way, and which could be imitated to good advantage in the preparation of much of the bituminous coal for the market, though more than three or four grades would be unnecessary.

Drainage.—The surplus water must be removed from the mine, which may be done by collecting in a conveniently located sump from which it is pumped to the surface. There are many cases where the siphon may be used to advantage in mine drainage, which will suggest themselves.

Ventilation.—The proper ventilation of a mine is essential for the removal of dangerous explosive and poisonous gases and the supply of fresh air to the miners. This is accomplished by means of furnaces or fans, but preferably the latter, which should be of large diameter and run at much below their ultimate capacity. The air should be divided in the mine so that each part will receive its share of fresh air, rather than a larger quantity of impure air. The large number of mine explosions which have occurred in apparently well-ventilated mines show that fresh air cannot insure against calamities of this kind, and point strongly to coal dust as an important factor in their make-up. It is probably safe to say, however, that coal dust and fresh air are harmless ingredients when undisturbed by outside conditions, which must bring to bear a sudden commotion of the air

to float the dust and a flame to ignite it, after which the disaster may extend indefinitely, as these conditions are then its own. The most probable origin of such an explosion in a mine comparatively free from explosive gases would be a blown-out shot in blasting, or the ignition of a small pocket of gas, in itself insufficient to do the slightest harm.

The proper drainage and ventilation of a mine depends largely upon the plan of working and this again upon an accurate knowledge of the field to be worked. This knowledge is sometimes gained to a certain extent by extensive prospecting before the mine is opened, but more frequently it is developed with the mine. In such cases an accurate and comprehensive map of the mine is of vital importance. This map should show all entries, rooms, pillars, cross-cuts, etc., together with data of a general character, such as thickness of coal, elevations and contour of the bottom, position and extent of faults, rolls and other disturbances, direction and degree of the dip, line of the slips, property lines on the surface, and any other information as it may become necessary or desirable.

Maintenance.—Freedom from danger and the delay due to accidents demand that the mine shall be kept in a safe and workable condition, which may be attained by a judicious use of timber in supporting the roof, the removal of loose and hanging portions of rock, and the exercise of due care on the part of the men. The roadways should be kept free from obstructions and in good repair to insure the safe transportation of the loaded wagons.

The mining of coal has grown in importance until at present it is one of the giant industries of the day, which place it will keep until the winds and waters can be made to give up their energy in a convenient form for the use of man, or until the invention of a simple and effective storage battery for obtaining that energy direct from the sun.

A NEW MEXICO COAL MINE.

By GEO. W. RICHARDS, of Carthage, N. M.

The San Pedro Coal and Coke Company's Mine No. 2 is located at Carthage, New Mexico. Work was started on this mine January 19th, 1887, and the main slope was driven down 120 feet as a prospect. Soon after getting under cover an irregular down-throw fault was encountered and from there to station 1 + 20 the top coal was followed. At 1 + 20 an up-throw brought the coal back nearly to the grade of the opening, and after testing the coal to find that it was of full size, a grade of 25.34 feet per 100 was established and permanent timbering and grading begun.

At the same time a system of outside tracks was adopted and all material taken from the opening was utilized in grading. The outside tracks had to be adapted to the hills at this point and as a railroad spur could not be located behind the proposed site of the hoister, or on a continuation of the line of the main slope, a back switch was put in and the trestle and chute located west of the mouth of the main slope, as shown on map.*

This system gives perfect control of the loads until they are on the chute and leaves the end of the rope handy to hitch on to the empties; it is objectionable only in that cars must be hauled up with the door end down-hill; if the door fastening gives way most of the coal is spilled.

On March 12th, 1887, entry No. 1 West was started 60 feet distant from the main slope and parallel thereto. It was the intention to carry these entries forward at about the same rate and to work the ground to the west from No. 1 West and that to the east from the main slope, but as entries were turned to the right from No. 1 West they all encountered faults and that entry was abandoned after making a connection with the main slope at station 2 + 15.

To develop to the east of main slope, a prospect was started at station 1 + 70, and after running about 75 feet to determine the dip in that section an entry was turned making an angle of 33° 10′ with the main slope and a regular curve with a radius of 86.6 feet was laid out and permanently timbered. This was called the 1st left. It has proved the most important entry up to date and will be further noticed hereafter.

A curve similar to the one at the 1st left was started to the right at 2 + 17, and after making an angle of 60° with the main slope was continued on tangent until it met a large up-throw fault at P. C. + 190. A down-throw could have been passed, but an up-throw would

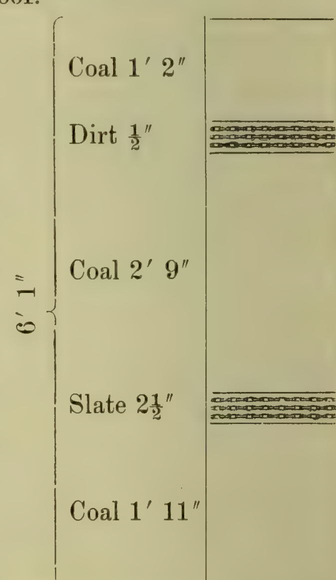
*A map and profiles of this mine were exhibiied but can not be reproduced here.

prevent reaching the face with the main hauling rope, and work in this direction had to be abandoned. This was the second failure to open the ground to the west of the main slope.

The main slope also reached troubled ground soon after passing the 1st left and is now standing on a series of faults at 3 + 40. It is still the intention to reach the line of the main slope by driving back from entries to the right of 1st left and afterwards grade the slope.

After the first 200 feet the 1st left off main slope has been in a comparatively clean field. There are faults as shown on map and profile, but they were encountered singly and not of such size as to seriously delay the work. This entry was driven as shown by black lines on profile and temporarily timbered by posts 7″ diam. 6½′ long with 2″ cull plank used instead of collars. Now that its value is known it is being graded to a uniform grade of 9.75 feet per 100 and permanent timber put in. This feature of opening up as a prospect and afterward grading and timbering permanently is rendered necessary by the broken character of the field. It is impossible to determine beforehand what importance a certain entry will be or what grade will best reach the coal along its course.

The roof is a bad one, there being from 10 to 12″ of slate immediately over the coal and above this top coal from 14 to 16″ thick. Even with the first opening of prospect entries trouble is encountered in this regard, and in some places the slate and top coal are both taken down, giving a good sand stone roof.



To help keep the roof, wooden cribs are built in where the long point is formed by turning entries and also along the side of roads skirting faults. In cases where an entry is driven close to a fault, on the same direction, all the coal is taken out at once and the crib built in; if this is not done, the coal soon splits off the fault and more or less rock from the V's of the fault itself will follow.

There are instances where the coal is pinched out, but as a rule the faults are clearly defined and no trouble is found in telling whether the fault is up or down. To tell how much it is up or down is a different matter, especially when it is more than the height of the coal and brushing. By driving straight ahead a short distance an idea can be formed by the rocks found facing the coal, but this is not always accurate since the ad-

jacent rocks are pinched and warped with the coal; the only way is to drive a hole only large enough for one man to work through, up or down the fault until its size is found and far enough into the coal to be sure it is regular—then come back and grade the hauling road to it.

A prospect hole can be carried quite a distance into a fault when it is down, but not very far up,—the exact distance will depend on the strength of air current and upon the endurance of the man.

All of the entry work, in coal, is done with the Harrison mining machine. We are thus able to work much farther "ahead of the air" than could be done by hand; in fact it is very questionable whether this field could be worked at all if the entry-driving had to be done by hand and parallel entries kept well up for the ventilation.

Three mining machines are at present working. A machine runner at 30c per hour and a scraper at 20c work with each. When a blast is to be put in, the runner moves his machine to another place, and a man comes in with a Howell's power drill and puts in a 2″ hole on each side, charges the hole with from $\frac{3}{4}$ to $1\frac{1}{4}$ pounds of 40 per cent. giant powder and shoots it. The loading into cars is done by native laborers at from 15 to 20 cents per hour; they are shifted from one part of the mine to another as the coal is ready for them.

Temporary timbering is done chiefly by the machine runner and his scraper or the driller, and a special gang follows after, doing the permanent work. The standard timbering is 10 to 12″ diam., collars 6′ 6″ between notches, legs 7′ long set at $\frac{1}{4}$ pitch, sets 4′ center to center and lagged over the top and in some cases down the sides, with poles 3 to 4″ diam., 4′ long. Special timber is put in at switches and at points where trips are gathered.

The ventilation is good and so far has needed no artificial aid. The difference in elevation of the openings is not great, but the heat of the mine and men, together with the exhaust air from mining machines, is enough to give a good current.

A 15-foot fan, made by W. E. Cole, of Washington, Indiana, is on the ground and will be placed in position as soon as suitable foundations can be built.

What has been said, taken in connection with the accompanying map and profile, will show this to be a very peculiar and expensive mine to work. It is so irregular that plans for working any particular part have to be constantly changed to meet the varying conditions—a plan that suits perfectly to-day will have to be changed entirely in a month's or possibly a week's time.

The section occupied by No. 2 mine is a fair example of what the whole field is, and no one acquainted with it expects to find any extensive area of clean coal. There is probably more to be learned as the field is more fully developed, but the very peculiar character of the faults and the irregular changes in the dip make it very puzzling. In most fields faults run with some regularity and when two points are known a third can be located with reasonable certainty;

with many of these faults nothing can be told, as they wander about in the most erratic manner possible and increase and decrease in the same way. For example the large fault 24 feet down on No. 1 slope just beyond the 1st right shows only by a 6-foot fault on the 1st left and the two points are but 50 feet apart. On the 1st left just beyond No. 1 East an 8-foot down-throw was struck and just beyond it a 21-foot up-throw; these were both clearly defined and the supposition was that they continued in this manner to either side. On driving No. 1 East it was found that the 8-foot down-throw ran out altogether and when No. 3 East was carried on below the 1st left it was found that both faults had scattered and made an irregular jumble—nothing definite at all but a series of ups and downs with small pockets of coal between.

The facts that this coal is of excellent quality for locomotive use, that it makes good coke and that no other coal field is worked within 250 miles, gives it value. The last is the strongest point. Were it located in any of the great coal producing regions of the east, or even of Colorado, this field would be of no value except for local crop workings. As it is, the prospect is favorable for several years steady work, or at least until some extensive fields are opened up near here which can be mined for less money.

PROGRESS OF WORK ON THE CAIRO BRIDGE.

By S. F. BALCOM, of Champaign.

Construction work on the Cairo bridge has been in progress something over a year. The contract with Messrs. Anderson and Barr for foundation work expired at the end of 1888, but the work had already been completed some little time. The stone work being built by Messrs. Loss and Wilson, will be completed by March 1 of this year, some months previous to the expiration of their contract.

The two deck spans on the Illinois shore have been erected; also the two channel spans, the longest in the bridge. The deck span on the Kentucky side also has been erected. In the Railroad Gazette for January 11, 1889, there are five views of the second one of these channel spans, showing the progress of erection during the four days in which this span was put up. I quote the following from that article: "It will be seen that the work was done in four days, which is doubtless the fastest erecting ever done. The trusses are 518 feet 6 inches long between end pins, 30 feet $5\frac{3}{4}$ inches panel length, 61 feet deep c. to c. of chords, and 63 feet 3 inches deep over all. They are 125 feet apart c. to c. of chords. and 28 feet wide over all. The shipped weight of one span is 2,055,200 pounds. The men employed were 87 to 93 per day, averaging 91. Of these 12 men

were in the yard handling the material and bringing it to the derrick, and 12 were occupied in delivering it to the traveler. The erecting gang proper consists of about 25 men for each truss, distributed as follows, on each side: 8 men on the top scaffold of the traveler, 4 on the middle scaffold and 8 at the foot, 2 at the ropes, 2 at the engine and 1 engineer. The other men were occupied in painting, and at various jobs on the false work. Two days before erecting began 29 car-loads of steel were delivered in the yard, which fact suggests the difficulty of having the material sorted and arranged for quick delivery in proper order on the work."

Besides this work on the bridge proper, some 3600 feet of pile trestlework has been completed on the south end of the Kentucky approach, and piles are being driven on the line of the approach between this pile trestlework and the bridge proper, for the foundations of the cylinders that support the 22 deck spans of the approach. The stage of water in the Ohio river prevents the erection of false work at present, but the work has progressed as far as was expected and will probably be completed by the time that has been had in view, viz., November 1, 1889. Should there be no delay in the arrival of iron work, the approaches will probably be completed as soon as the bridge proper, and the entire structure will be in use at the end of this year.

Mr. Alfred Noble has been in charge of the work as Resident Engineer, assisted by a corps of several assistant engineers, of whom Mr. E. Duryea, jr., and Mr. Addison Conner have been on the work since its beginning.

A rise of water in the river has interfered with the work a few times. It submerged the foundation of pier No. 9 in January, a year ago, and the current caused considerable trouble by scouring at the northwest corner of the crib work. I mentioned in the paper read at the last annual meeting that the excavation made by the current at this pier was at the up-stream end of the foundation and that the north end of the caisson followed the excavation. I misunderstood information given me, and wish to correct the statement. The scouring was around the northwest corner of the foundation, and the excavation reached a depth of 16 feet below the bed of the river and 2 feet below the cutting edge of the caisson. The foundation was thrown somewhat out of position, but not over three feet out of level. A protection of riprap and sand bags was made, and the foundation lowered and shifted into position again. At a depth of about 15 feet below the bed of the river, a large tree was encountered, extending the full length of the caisson mentioned; and at a depth of about 20 feet, another tree was found under the north end of the caisson. Excavation was discontinued January 30, but was resumed again for a short time in February; it was again abandoned and nothing further done until the next August, when work was resumed and carried on to completion.

Trouble was also caused by a rise in the river about the first of

last September, when the falsework for the channel span next the Illinois shore was wrecked. The falsework consisted of 60-foot piles, driven not less than 20 feet into the bed of the river; these were capped, and three stories of trestlework framed on top, making a height of something over 70 feet above caps on piles. The falsework had reached about half way across the span, when drift-wood lodged in the bents to such an extent that the strong current lifted the falsework, pulling up or breaking off the piles, and swung the wrecked mass around next to the Illinois shore. The falsework was again erected; and after the truss had been put in position, it was taken down, the piles drawn and redriven for second span, and the framed bents were transferred to the second span without taking them to pieces.

A great deal of trouble from the "bends" was experienced by the men, when working at low depths. Some of the work was done at a depth of 94 feet. However, but four men lost their lives in this way; although a large number were more or less affected. Paralysis is one of the extreme symptoms; and the men are affected by it in different degrees.

Without stating exact figures, the following is the proposed plan for connecting the bridge proper with the main track in Illinois and in Kentucky. The bridge is approached from the north on the present main track, a tangent several miles in length, and on a level grade, somewhat above high-water line. After branching off, the approach continues on in a straight line nearly parallel with the present main track, and just west of it, until the city limits of Cairo is reached. For about half a mile from the junction with the main track, it will be composed of pile trestlework, with a grade of about 40 feet per mile. Next to this will be wooden trestlework, on pile foundation, for about one-half mile, most of it being on the grade named. Five hundred feet of the south end of the wood trestlework just referred to will be on a five degree curve to the left, with a grade of about 32 feet per mile. This brings the approach to the Cross Levee at North Cairo; and from this point to the bridge proper, the approach will be composed of seventeen deck spans, 150 feet long, supported by iron cylinders filled with concrete, which rest on a pile and concrete foundation. This portion of the approach is partly on the five degree curve mentioned; the eight spans next to the bridge, being straight, are on a grade of about 40 feet per mile. Next to the north approach are the two deck spans in the bridge proper; they are something over 250 feet long, each, between center of piers. Next are the two through spans, each 523 feet long. Following these are seven through spans of about 400 feet each. At the end of the bridge on the Kentucky side is a deck span similar to the two deck spans already mentioned. The alignment of the bridge proper is straight and has very nearly a due east and west course. It lacks only about the length of one of the channel spans of being one mile in length and is built on a level grade.

From the east end of the bridge the south approach starts on a five degree curve to the right, and has twenty-two deck spans similar to those in the north approach; the first twelve of which are on a 32-foot grade, and the balance, as well as the remainder of the approach, on a 40-foot grade. Next to the iron work is to be placed about 1,000 feet of wood trestle, which will connect with the pile trestle already completed. The length of the bridge when completed, including approaches, will be nearly four miles.

The foundations of the three channel piers are 30×70 feet and about 50 feet high; composed of a caisson and timber crib-work filled with concrete. On this foundation is placed something over 125 feet of stone work, and the height of the truss above is over sixty feet; so that the distance between the top of truss and bottom of caisson is over 240 feet. The foundations rest on beds of sand or gravel, which is considered a good foundation if the bed of the river does not wash. The current of the river in this locality does not change, consequently the river bed is not subject to scouring as in some localities. The trouble at pier nine already mentioned was probably caused by the rectangular form of the crib work, which offered a strong resistance to the current and produced an eddy or cross current, that did the scouring. The form of pier work is pointed, and is that which offers the least resistance to the current.

The piers for the deck spans in the approach are formed by two iron cylinders, eight feet in diameter, made by riveting 5-foot sections of boiler plate iron. They are braced and tied together and filled with concrete, and vary in height from 20 to 32½ feet. The foundation for each cylinder is made by excavating a pit about eight feet deep and ten or twelve feet in diameter, and driving, in the center, a cluster of twelve piles. This brings the piles quite close together, but they are kept far enough apart, by using wedges if necessary, to allow concrete to be placed between all the piles. These piles are from 32 to 38 feet long and are driven to about the surface of the ground; the split or splintered portions are cut away, and a bed of concrete about three feet deep is placed in the bottom of the pit. The concrete used is made of the same proportions as that in the crib work of the river piers, viz: four parts of stone, two of sand and one of natural cement. On this bed of concrete the iron cylinder is placed, inclosing the top portion of the piles and filled with concrete. Around the cylinder is placed a wooden curbing, and six inches of concrete is filled in between it and the cylinder, and carried up somewhat above the surface of the ground. Portland cement is used for this outside coating, also for the upper two feet of filling in the cylinder. Where the ground is low a deeper bed of concrete is put in the bottom of the pit; this leaves a shorter length of the piles extending up into the cylinder, and in such cases four of the piles are left standing two feet or so above the balance, and iron rods are used to anchor the cylinder to the foundation.

A great many are curious to know how the new bridge will affect the city of Cairo. The north end of the bridge will be some $3\frac{1}{2}$ miles from the Cairo passenger house, and to reach it, trains that have crossed the bridge will have to be pulled back into Cairo; and if south-bound trains go to the Cairo passenger house before crossing the bridge, they will have to be hauled back the $3\frac{1}{2}$ miles before they can go over the bridge. This would make seven miles of additional travel on the route between Chicago and New Orleans; and as this distance is in the city, the speed must be slow and the delay very considerable.

That the bridge will be a great help to the Illinois Central railroad, is very evident, as its business is constantly increasing and the delays that attend a boat transfer make the handling of a large amount of traffic in a limited time impossible. The general manager of the Illinois Central recently had occasion to call the attention of the city council of New Orleans to the fact that the fruit trade had very greatly increased in the last few years, and stated that only 50,000 bunches, or about 80 cars, of bananas were received in New Orleans in 1880, while the amount had increased to 2,500,000 bunches, or over 4,000 car-loads, in 1888. He also called attention to the fact that the United States imports, annually, nearly 500,000,000 pounds of coffee. Brazil furnishes about 75 per cent. of it, and Venezuela and Central America nearly all of the balance; and New Orleans should be the port of entry for a very large portion of it. Also, the United States exported last year 35,000,000 bushels of corn, of which 7,000,000 were exported from New Orleans; and because of New Orleans being nearer the corn producing states, it should be able to export very much more of that article than at present. Brazil, with the Spanish-American republics and West India Islands, has a population of about 50,000,000 people, and but 10 per cent. of our entire exports go to them; when, at the same time, their imports amounted to about 70 per cent. of our total export trade. The Illinois Central system should handle a large portion of the export and import trade that properly belongs to the large southern, western and northwestern sections. Should this be accomplished in other lines as successfully as has been done in the fruit trade, the single track bridge now being built will be taxed to its utmost capacity to carry the traffic, and probably the only fault that will be found will be that it is not a double track bridge.

DISCUSSION.

Mr. Loring—How high is the bridge above high water mark?

Mr. Balcom—About 105 feet.

Mr. Baker—I was at Cairo last summer and they were putting in a plant to cool the air for the men in the caissons, and I would like to ask what was the result.

Mr. Balcom—The experiment on the whole, I understand, was a success. I was told that it changed the temperature about 20°.

METHODS OF MEASURING AND COMPUTING EARTH-WORK.

By E. L. MORSE, of Cazenovia.

It is not my intention to introduce any new methods for measuring or computing earthwork, nor attempt to put any one method forward as the best. No one method can be applied to all cases, and the engineer must adopt the one most suited to the work in hand. I wish briefly to refer to certain points, however, which apply to any method used.

The "minor details," as they are usually called, which taken together make up the greater part of the engineer's work, are not more than mentioned in a general way in works on engineering subjects, so that there are many things to be learned in practical work that were not thought of before. It is in these minor details that the greater part of the mistakes of practice will occur. A difficult curve will be located exactly; an important measurement will be checked and rechecked; but an omission will be made in the notes of a culvert opening, a road crossing or some matter similarly small, which sometimes assumes large proportions later, when there is a question raised, and no notes are to be found.

In the measurement of earthwork of any kind, excavation or embankment, for railroad or other purposes, the principal points to be observed in the field work are:

1. Obtain notes that will give correct results when computed; that is, they shall correctly represent the ground measured.

2. The notes should be clear and not ambiguous, not only to the one who takes them but to any one else familiar with the subject. It does not require any more time or effort in the field to make a neat, compact page of notes than it does to cover two or three pages with what should be put on one, and oftentimes an engineer's reputation will depend to a great extent on this one thing.

3. Make complete all notes in the field where any question could arise as to whether they might not be different; and note any omission of measurements that may be necessary.

The exact manner of keeping the notes, whether the distance out shall be above the line and cut or fill below, or *vice versa*, or whether the notes shall be kept from the bottom of the page up, or from the top down, are matters of personal convenience or habit and for uniformity are often regulated by the company for whom the work is being done.

Accuracy with the instrument and tape are important, but this accuracy is often carried out to a greater degree than necessary. The idea that by giving the rod readings to hundredths in ordinary cross-section measurements, the exact amount of earth in a section is more nearly obtained, is erroneous. If the surface of the ground were a perfect plane between consecutive cross-sections this would do; but even in ordinary level country a slight elevation or depression in the ground, or a change of a few feet in the location of the cross-section will often change the rod reading a tenth or perhaps more, so that beyond a certain point we do not gain in accuracy of results by closer rod readings.

Correct results depend much more on the care and judgment exercised in making the cross-sections at the right places—especially in rough and broken country where a great deal of averaging is required.

It is always desirable to make as fast progress as possible in measuring up work, and also to do it easily, for there is, comparatively speaking, a hard and an easy way of doing the work. The engineer who will so plan the work that the most time and labor can be saved—other things being equal—is the best man. There are many ways by which the work in the field may be facilitated; for instance, it is unnecessary to find the elevation of each point taken and then the difference of that point and grade to get the cut or fill; take the difference between the height of instrument and grade, and this gives the number to which the rod readings at the different points of a station are to be added or subtracted. This may seem too simple and apparent to need mentioning, but I have seen men of practical experience who still used the long way.

In setting slope stakes in a moderately level country it is quite convenient to have a tape marked with the cut or fill at the proper distance out; this marking may be done on the back of a linen tape with common pen and ink and does not injure the tape for measuring; for example to mark a tape for a 16′ railroad embankment, slope 1½ to 1, beginning at the 8′ mark on the tape, for a fill of 0.1 make F 0.1 at 8.15, F 0.2 at 8.30, F 1.0 at 9.5 and so on. This enables the tape man to set the stake at once as soon as cut or fill is given and prevents mistakes in getting the wrong distance out.

In rough country where there is considerable difference in elevation between center and side, or on side-hill work, the slope board and rod are indispensable. The slope board is usually ten feet in length, one edge straight, the other usually rounded, widest in the middle where a hand-hole is cut and a small level bubble placed. The level rod is held vertical at a station, one end of the slope board is placed against this, the other on higher ground; the board is raised till level and the difference of elevation is read on the rod. There should be a line of levels at both top and bottom of slope to check on when possible, but a good degree of accuracy may be obtained with the slope board, and much faster progress made on steep side-hill than by any other method.

There are so many methods used in the computation of earthwork and so many formulæ, tables and diagrams prepared that I could hardly mention all of them, and no one formula can be selected that would apply to all cases. The nature of the work and the ground will usually determine, to a great extent, the method to be used.

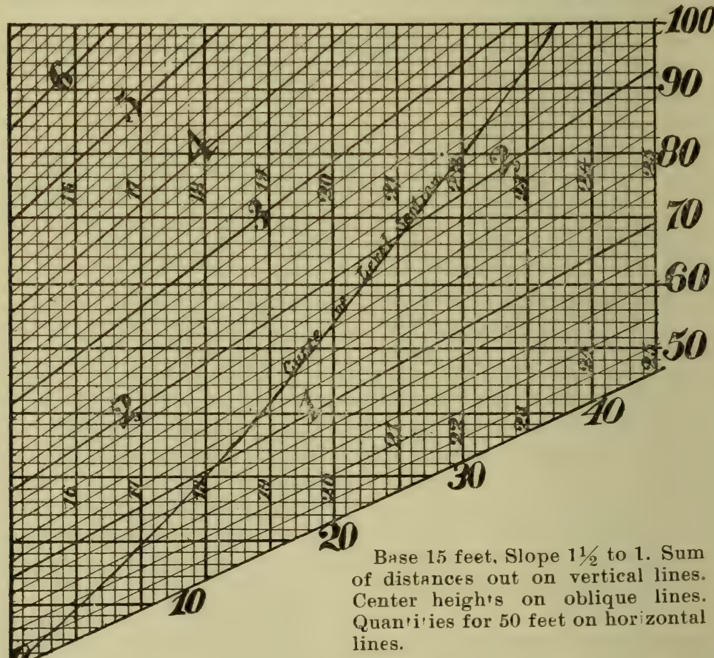
The most simple and hence the easiest of application is the method of average end areas, that is, one-half the sum of the areas of the end sections multiplied by the length of the section and divided by 27 for the number of cubic yards. Its simplicity and convenience of application makes it a very popular method. In the state of New York, and perhaps other states, it is approved by statute to be used on public works; it is also used exclusively by many of the railroad companies for computing earthwork.

Probably the most exact method of computing earthwork is by the prismoidal formula, which is $S = \frac{L}{6 \times 27}(A + 4M + A')$, in which S = cub. yards, L = length of section, A and A' = areas of the end sections, M = area of a middle section. The area of the middle section is not a mean of the two end areas; but the dimensions of the middle section are means of the corresponding dimensions of the end sections. While accurate results may be obtained by this formula it requires too much time and is too tedious in its application for general use.

However, if a close result can be obtained by the method of end areas there will be no need to use the longer method; so a few comparisons may not be amiss. Taking an ordinary cross-section for railroad embankment, 14′ road bed, slope $1\frac{1}{2}$ to 1; supposing the ground to be level transversely, for a 6′ fill at one end of the section of 100′, and a 2′ fill at the other, giving a difference of 4′ between the two end fills, and computing by both methods, we have by end areas 318.5 cubic yards, by the prismoidal formula 304.0 cubic yards, giving a difference of 14.5 yards. If the first end section remains 6′ fill and the second be 4′ fill, leaving a difference of 2′ in fill between the two ends, the results are by end areas 403.7 cubic yards, by prismoidal formula, 400 cubic yards, giving a difference of 3.7 cubic yards. Again, comparing the section with 6′ fill at one end and 5′ at the other, leaving a difference of 1′ fill between the ends, the difference in results is quite small, being less than one cubic yard. The comparisons made are enough to show, to some extent, the amount of error in computing by end areas and under what conditions the results by this method are approximately correct. A difference of one foot in cut or fill between the end sections makes no greater difference in the results by the two methods of computation than might occur in measurement in the field, and we can not well be more exact in one part of the work than in another; it is needless to compute to hundredths of a yard when the measurements can not be taken closer than tenths of a foot.

I believe that the method of end areas can be used in most cases with good results. The large difference in areas of adjacent sections may be, to a great extent, obviated by taking intermediate sections in the field; where this can not be done a correction, determined by the difference in areas, may be subtracted or added, and this with much less labor and more speed than to compute by an approximate prismoidal formulæ.

There are a number of different kinds of tables and diagrams computed and arranged to facilitate the labor of obtaining the quantities from the notes, some of which are very good while others always seemed to be more laborious than to use the formula itself. I wish to speak of but one of these tables, or set of diagrams rather, after Wellington's method, which for level country, where no readings occur between the center and slope stakes, are very convenient and practicable. The formula by which the diagrams are computed is $S = \frac{50}{54} (c + \frac{w}{2r}) D - \frac{25w^2}{54r}$, in which $c=$ centre height, $w=$ width of roadbed, $r=$ ratio of slope of cut or embankment, $D=$ sum of distances out, and $S=$ volume in cubic yards for a length of 50 feet.



Base 15 feet, Slope $1\frac{1}{2}$ to 1. Sum of distances out on vertical lines. Center heights on oblique lines. Quantities for 50 feet on horizontal lines.

The method of construction of the diagram may be explained in connection with the small portion of one shown in the cut. Take a sheet of cross-section paper ruled to tenths. Consider that the

horizontal lines show volumes in cubic yards, or S; the vertical lines distances between slope stakes, or D. The former will number from the bottom upward; the latter from left to right, the left line being numbered equal to the width of roadbed and in this case each vertical line representing an additional 2 ft. To draw the diagonal lines—substitute in the given equation $D = w$, giving $S = \frac{50\,w}{54}c$, which for a 15-ft. roadway $= \frac{750}{54}c$. Calculate S for the different values of c and lay the resulting amounts off on the left vertical line. Calculate S for some other value of D, as 25 feet, which in this case will give $\frac{1250}{54}(c+2)$. Lay off these values on the 25-ft. vertical line counting from the bottom of the rectangle as before. Connect these points with the corresponding points in the left vertical line, and these diagonal lines will represent the center heights. The curve of level section, a parabola, may be drawn by computing the S for different center heights and connecting the resulting points on the diagram.

To use the diagram, follow the diagonal line representing the given center height until it crosses the vertical line corresponding to the given distance between slope stakes; the horizontal line passing through the same point will give the desired cubic yards. The sum of the amounts obtained for consecutive sections will give the volume in 100 feet. When the sections are closer, take proportional parts of this volume.

A diagram for triangular prisms computed by the usual formula, $\frac{1}{2}$ base $\times$ altitude, also a prismoidal correction sheet, may be arranged; the formula for the latter is $\frac{c - c'}{3.24}(D - D')$ and is platted in a similar manner.

A short practice will enable any one to take out quantities from the notes quite rapidly with these diagrams and with as correct results as from any table.

A method that one engineer considers good, easy of application, correct, &c., will not be used by another, because, becoming accustomed to one way of doing work, want of time or inclination prevents his examining any other.

In all engineering works where earthwork is to be measured and computed, the final results as regards accuracy in obtaining true quantities will depend more on the work done in the field than in computing the notes. This does not necessarily mean close rod-readings, but an exercise of care and judgment in selecting the sections and ability to rightly average slopes and rough ground. The notes show only what has been done in the field and do not give right results except when they correctly represent the surface measured.

DISCUSSION.

Mr. Talbot—In the calculation of earthwork, a discrimination should be made between the absolute error and the per cent. of error. The latter should be kept in mind rather than the former. Accuracy is a relative term, and the refinements of calculation should never exceed the accuracy of the field work. Of course this allowable per cent. of probable error should vary with the cost of the earthwork. An intermediate cross-section in the field is of more value than many decimal places in the computation. It is quite possible with fairly careful cross-sectioning for the *hundredths* of a foot in both grade line and height of instrument to conspire to render the cut or fill of a section $\frac{3}{4}$ of a tenth in error. This for a center height of eight feet will give an error of eight or more cubic yards in 100 feet. While this is an error of only one per cent., it shows the folly of calculating contents to hundredths of a cubic yard. Again, the irregularities of the ground between sections and the usual deficiency of the earthwork will give even larger errors than this. The engineer should see, therefore, that the data from the field work is accurate enough to give results within the allowable limit of error.

It is not generally known that for level cross-sections the correction for the excess given by averaging end areas varies directly as the square of the difference between the adjacent center heights and is independent of roadbed or actual center height. The value of this correction for a 100-ft. station is $\frac{2\,r}{3.24}(c'-c)^2$, c and c' being the center heights, and r the side slopes—a very simple formula. Even when the side heights differ from the center heights, if the transverse slope of the ground is uniform or nearly so, the error by using this formula will be small.

The following table gives this prismoidal correction in cubic yards for 1 to 1 side slopes. For $1\frac{1}{2}$ to 1 slopes the values will be one-half greater; for 2 to 1 slopes, twice as large, etc. For sections less than 100 feet apart, the correction will be a proportional part of these values; 50 feet will be $\frac{50}{100}$ of that in the table; 10 feet, $\frac{10}{100}$ etc. Though computed to tenths, it is generally not wise to attempt to compute closer than yards.

PRISMOIDAL CORRECTION TABLE.

$c'-c$	cu. yds.	$c'-c$	cu. yds.	$c'-c$	cu. yds.	$c'-c$	cu. yds.	$c'-c$	cu. yds.
1.0	0.6	3.0	5.5	5.0	15.4	7.0	30.3	9.0	50.0
1.2	0.9	3.2	6.3	5.2	16.7	7.2	32.0	9.2	52.2
1.4	1.2	3.4	7.1	5.4	18.0	7.4	33.8	9.4	54.5
1.6	1.6	3.6	8.0	5.6	19.4	7.6	35.6	9.6	56.9
1.8	2.0	3.8	8.9	5.8	20.8	7.8	37.5	9.8	59.3
2.0	2.5	4.0	9.9	6.0	22.2	8.0	39.5	10.0	61.7
2.2	3.0	4.2	10.9	6.2	23.7	8.2	41.5	11.0	74.7
2.4	3.6	4.4	12.0	6.4	25.3	8.4	43.6	12.0	88.9
2.6	4.2	4.6	13.1	6.6	26.9	8.6	45.7	13.0	104.3
2.8	4.8	4.8	14.2	6.8	28.6	8.8	47.8	14.0	121.0

Mr. Hansel—I find so many irregular cross-sections where tables are not applicable, that the computation of the end areas by calculating the trapezoids composing the section becomes necessary. With a little practice this computation may be made very quickly.

Mr. Talbot—This is especially true in raising grade on old embankment, where ten or more readings generally occur in each section. Even then I have made tables which reduced the labor of computation.

Mr. Rottman—My method in excavation in city work is to take readings on the sections at regular distances apart, say 20 feet. This greatly facilitates the computation. Monthly estimates are made from elevations taken at these same points.

Mr. Cantine—Will the quantities given by tables and diagrams based on the prismoidal formula stand in court? I have heard the statement made by engineers that nothing but the quantity computed by averaging end areas will be accepted as the true cubical contents of earthwork. I once had to re-calculate 20 miles of work on this statement.

[*Answer*—In general, the prismoidal formula is the only correct method—especially if the specifications read, as they usually do, "by the cubic yard from the true measured prismoids indicated by the cross-section notes or slope stakes of the engineer." The statutes of some states require the use of averaging end areas on government work."]

A PARK TOPOGRAPHICAL SURVEY.

By E. I. CANTINE, of Bloomington.

The particular survey of which this paper is descriptive is that of Miller Park, Bloomington, Ill. This park embraces a tract of land 1480 feet in length east and west by 1150 feet in width north and south, containing 43 acres more or less. The survey to be discussed was the preliminary step for the further work of preparing the landscape plans.

The ground is generally quite rolling, but in parts somewhat broken. There is an extreme difference in elevation of 44 feet. It has a natural water-course or draw, draining about 80 acres of land, passing through it. The park is carpeted with a heavy sod, which is as nature placed it, the ground having never been broken. There are some sixteen or more varieties of our native forest trees growing, embracing the red, white and burr oak, the elm, linden, hard maple, shell-bark, and pignut hickories, walnut, butternut and others. The trees will range in size from 4 to 60 inches in diameter. The number of trees will approximate 1235.

The survey was made for the Park Commissioners, Messrs. J. H. Burnham, C. F. Koch and Wm. L. Evans, and reported to A. H. Bell, City Engineer. The object was to make a complete topographical survey of the land, showing 2-ft. contours, locating and describing trees, giving their size and name, locating buildings, fences, etc. The fact that there were so many trees rendered it inadvisable to use either the plane table, plane table and stadia, or stadia methods of surveying. The plan pursued was as follows: The surveying party consisted of an instrument man and two assistants. A Gurley transit with delicate horizontal level served as a leveling instrument, as well as for transit work. A line of stakes 100 feet apart was first driven across the north side of the park, and a similar row through the middle of the park. The instrument was set up over stake on middle line of park and sighted to similar stake on north side, the chainmen chaining in stakes 100 feet apart from the north to south, necessitating generally but one setting up. The north and south lines were designated by the letters of the alphabet, the first line on the east being "A" line, the second "B" line, etc. The east and west lines were designated by figures, C° indicating the beginning of C line (on the north side.) D^4 indicates a point 400 feet south on D line. When the last stake had been driven on the south side, the instrument man pulled up and moved to the north side, and

set up to run the levels, his assistants returning to that side. Readings were taken every 100 feet and as many additional pluses as were necessary to show any change in slope. Side readings were also taken wherever necessary. When a line of levels was completed, the party was on the south side ready to work back, locating trees, buildings, etc. All trees fifty feet on either side of line were located. To locate the trees, a 75-ft. Chesterman tape was used (100-ft. would have been better). With one assistant at the tree and the other at the nearest station, the instrument man lined himself in and estimated by eye when at right angles to the tree, and then read off from the tape the distance to the tree, subtracted this from the distance read off by the one at the station, and noted in field notes by platting the plus and distance of tree to right or left, together with size and kind of tree. Checks showed that the error of estimating the right angle was generally within 1 foot in 50 and always within 2. In this manner the entire survey was completed. It required about nine days for the party to make the topographical survey, additional time being used to make borings, etc.

The field notes were kept in a book of cross-ruled paper, ruled into squares fifteen to every two inches. Each square was considered five feet on a side, which made the field notes on a scale of thirty-seven feet to the inch, large enough to locate the trees graphically by a dot within a circle, placing letter denoting kind of tree and a figure giving diameter in inches by each mark. The level notes were kept as ordinary level notes with the addition of any sketches that would aid in the location of contours.

The map* was drawn on mounted white paper to a scale of 50 feet to the inch, a scale large enough to work from in planning the landscape designs. The parallel lines 100 ft. apart having first been drawn, the trees and buildings were located from the field notes.

The contour lines were determined as follows: Let the elevation at station 1 be 102.5, and at station 2, 109.3; difference 6.8 feet, or .068 ft per foot; then by proportional distances the 104.0 contour line would come at + 23, the 106.0-ft. line at + 53 and the 108.0 contour at + 83. This may easily be found graphically. In a similar way points were determined to the right or left of the station, and the contour line drawn through points of similar elevation. The sketches made in the field were also utilized in giving a general direction to the contours.

In inking, the equidistant 100-ft. lines were drawn in with a light tint, the contour lines in neutral colors, the trees and buildings in black. Some such plan was necessary to bring out the trees and contour lines in contrast, there being such a large number of trees.

In following the method of survey described, it is thought it was the one best adapted to the tract of land to accomplish the end in view, being rapid and at the same time sufficiently accurate.

*The map was on exhibition but can not be reproduced here.

BY WHAT RULES OF LAW ARE COURSE, DISTANCE AND AREA GOVERNED, IN THE SUBDIVISION OF THE GOVERNMENT SECTIONS?

By Z. A. ENOS, of Springfield.

The belief that very erroneous ideas are frequently entertained as to much of the law applicable to our real estate, growing out of a want of familiarity with, or a misunderstanding of the United States land laws and land system, and also from implicitly following the decisions of the courts in the old States, in which neither those laws nor that system have any force or application (all their legal principles and rules governing landed interests are alone found in the common law and their own local enactments), has induced me to take up and discuss some of the points wherein, it appears to me, a mistaken view of the law is prevalent. The points that I propose to consider are, what is to be understood by the terms north, south, east, west, miles, half-miles, chain or chains, and contents or areas, as the terms are used in the United States land laws, and applied in the government surveys to the lines of the townships, sections and subdivision of sections; and what construction is to be given them, when the words are used in the ordinary deeds of conveyance by metes and bounds of a part of a regular section or quarter section, or so many acres, a part thereof.

In considering the subject, the United States constitutional provisions and the laws passed in pursuance thereof, relating to the public lands, must necessarily be the first thing investigated. Now, the constitution of the United States has conferred on congress the power to dispose of and make all needful rules and regulations respecting the territory or other property belonging to the United States; to establish standard measures; and to make all laws which shall be necessary and proper for carrying into execution the foregoing powers. These powers, from their nature, are exclusive, and preclude any concurrent legislation by the States. In pursuance of the authority thus conferred, congress has enacted a series of laws upon the subject, which are usually known and designated as the United States Land Laws, and which authorize and regulate in detail the manner of disposing of the public lands, beginning with the survey and subdivision of the territory into townships, sections and parts of sections, with plats and returns of the same, followed by public sale or private entry and certificate of purchase, with final closing of the disposal by patent to the purchaser—all being done and performed by the lawfully empowered agents of the government and in the

manner as provided by the acts. The more important of these acts, and which bear directly upon the points under consideration, are the acts of May 18th, 1796, May 10th, 1800, February 11th, 1805, April 25th, 1820, and April 5th, 1832.

The Act of May 18th, 1796, prescribes the manner of running the township and section lines in the division (or survey) of the public lands, viz.: "by north and south lines run according to the true meridian, and by others crossing them at right angles, so as to form townships six miles square, and said townships shall be subdivided into sections containing, as nearly as may be, six hundred and forty acres each, by running through the same, each way, parallel lines at the end of every two miles, and by marking a corner on each of said lines at the end of every mile."

The Act of May 10th, 1800, made provision for the complete subdivision of a township into sections, by the actual running of parallel lines and marking corners at the distance of every mile on the north and south lines, and every half mile on the east and west lines, and requiring the excess or deficiency of measurement to be added to or deducted from the western and northern ranges of sections; and the sections and half sections bounded on the northern and western lines shall be sold as containing only the quantity expressed in the returns and plats respectively, and all others as containing the complete legal quantity (viz.: 640 acres).

Now, as any straight line on the earth's surface, which cuts two meridians on the same side of the equator at right angles is a parallel of latitude, it therefore follows that each right line crossing the two meridian lines of a township at right angles is a parallel of latitude, and of course an east and west line, and consequently, by the terms of the act, the four sides of the township are required to conform to the four cardinal points, and be north and south and east and west lines; and as the subdivisional section lines of the township are required by the same act to be run parallel with the township boundary lines, the section lines also must be north and south and east and west lines. Nor is it a valid objection, that, as the east and west sides of the township are required to be meridian lines, owing to their converging they are not parallel lines, and that the subdivision section lines cannot be run parallel to both, and if parallel with either that they would not be meridians; for these section lines being run at the same bearing or variation of the needle as the township lines, they are for all practical purposes parallel lines and north and south lines, within the meaning and contemplation of the act, as much so as the township lines are meridian lines and six miles apart as required by the act. And as all these lines were run by sworn officers of the government, and in the discharge of their official duties, the presumption of the law would be that the officers performed their duty, and that these lines were run in conformity with the requirements of the act, and the courts would hold that prima facie they were north and south and east and west lines.

This would be the state of the case, was there no other legislation upon the subject. But the 2d clause of the 2d section of the act of February 11th, 1805, declares that these lines "as actually run and marked in the surveys returned, shall be *established* as the *proper* boundary lines of the sections or subdivisions for which they were intended." Thus not only declaring these township and section lines to be established, that is, permanently and unalterably located and fixed, but that they are properly so established, properly as conforming to all the requirements of the law. Among the most important of these legal requisites, is that that these lines should run north and south and east and west; or in other words, the statements of matters of fact as set forth and shown by these returns, are to be regarded as established, indisputable truths, and further, that those facts so set forth are a proper compliance with the intent of the law. Thus this last act makes that which was before a prima facie case, now conclusive, beyond all doubt or cavil. Nor does it make any difference whether these township or section lines are or are not, as a matter of fact, actual geographical meridians and parallels of latitude; for it is their legal status and character and not their geographical accuracy that is established and determined by these acts, and which also establish their proper or true governing and controlling character as meridians and parallels of latitude, or north and south and east and west lines.

Now, as the four boundary lines of a township or section are, by force of the foregoing acts, to be regarded as proper or true north and south and east and west lines, it necessarily follows that any subdivisional line of a section run parallel with or equi-distant from the exterior boundary lines of the section, as for instance, from an established corner to an opposite corresponding corner, in accordance with the provisions of said 2d section, such as the half and quarter section lines, and the half-quarter and quarter-quarter section lines, and in fact the lines of all smaller regular subdivisions of a quarter-quarter section, must be north and south and east and west lines; and further, that all lines directed to be run in the manner as specified in the last part of the 2d clause of said 2d section, from an established corner due north and south or east and west to a water course, Indian boundary line, or other external boundary of such fractional township or section, should also be run parallel with or at the same bearing or variation as that of the township or section lines. For it cannot be supposed that the government, having in the township and section lines established its own standard meridians and parallels of latitude, and declared them to be indisputably correct, should have also directed or authorized, or in any manner intended to sanction, the subsequent running of other and different lines, and such as were variant and conflicting with those it had already established and declared correct, even if done by its own sworn deputies, much less if done by a county or private surveyor.

Any other conclusion would lead to great confusion and conflict;

for if each surveyor was required, in the division of such a section, to establish his lines upon meridians and parallels of latitude, independent of all connection with or parallelism to the section lines, there would be as many of these lines radiating from each given point as there were surveyors running them; for in but rare instances would it justify the devoting of the time and labor requisite for making the accurate observations necessary to the running of such meridian or parallel lines; and as each surveyor would run the lines upon a supposed variation of the needle for the particular locality, and with compasses each running a different line at the same given variation, and without any guide or check for even the diurnal variation of the needle, there could not possibly be any accuracy or uniformity in these lines.

And further; if the township and section lines are not to be regarded as the legal meridians and parallels of latitude, or north and south and east and west lines, and when the words are used in these acts of congress, or in a patent, deed, or other conveyance of government lands, the lines are to be run according to the actual geographical meridians and parallels of latitude, regardless of the government survey lines (the latter in fact not being, or rarely being, actual geographical lines, and in some instances varying several degrees therefrom), then in what wedge or gore shapes would it cut the sections, and how few deeds for any part of a section, quarter section, half-quarter section, or quarter-quarter section could be placed and fitted entirely upon the regular government subdivisions, out of which they were intended to be exclusively taken and to which confined.

At the time the U. S. land system was inaugurated, there was in existence, in all the old states, an irregular mode of land location and claim, by survey from the magnetic meridian, or by magnetic north and south and east and west lines, and patents and deeds for the land from the state and individuals were in conformity with these surveys; and the terms north and south and east and west, when used in the descriptions of the land, were held and construed by the courts of those states to mean the magnetic north and south and east and west; and the United States, in inaugurating its land system, instead of following the old system of magnetic meridians, struck out a new line of survey, and adopted the geographical meridian and parallels of latitude for the basis of the system. The expressions "true meridian" and "due north and south and east and west," contained in the acts of 1796 and 1805, and often cited as authority for the running of north and south or east and west lines independently of all parallelism with the section lines, have no special or other meaning or significance than to distinguish these geographical, or so called true meridians, from the magnetic or false meridians, and the geographical or due north and south or east and west from the erroneous, or magnetic north and south or east and west; and in this sense were the qualifying adjectives "true" and

"due" used to separate and mark these two classes or kinds of lines; and not to strengthen or intensify the words meridians and north and south or east and west; for no line can be more than a meridian or more than north and south or east and west.

Now, as these laws are to be construed so that all their provisions shall, if possible, work together in harmony, then, unless some clear, emphatic reason can be given to the contrary, we would be compelled by the foregoing considerations to conclude that all the government subdivision lines of a section or quarter section, whether running from an established corner to an opposite corresponding corner, or in case where no opposite corresponding corner is fixed or can be fixed, are to be run, or are to be considered as running, so as to strictly harmonize with and be parallel to the section lines, the same as the section lines are to be parallel with the township lines. If the foregoing positions and conclusions are correct, it clearly follows that all descriptions of land by deed or other writing which call for a part of a section by courses and distances running north and south and east and west, must be construed to mean as running with or parallel to its section lines or regular subdivision lines.

And then, in regard to the distances or lengths of the government lines. The 2d clause of the 2d section of the act of February 11, 1805, further provides that the lengths of the lines actually run and marked in the surveys returned *shall be held and considered as* the *true length* thereof. Thus the act gives to the lengths of these lines the same character of fixed, incontrovertible facts, that it attaches to the corners and boundaries of the sections; it makes the returned length of every line actually run and marked in the surveys returned, in effect a standard measure of length, by which all subsequent chainings of the lines are to be governed, and by which the lengths of our chains are to be tested in any subdivision of the lines. Thus, as each half of the exterior lines of a full section (on the east and west side) was actually run and marked in the surveys returned, and the length thereof returned was 40 chains each, then, by the law, 40 chains is the true length of each of these half section lines, no longer and no shorter, and consequently one chain is the exact 1-40th part of the whole length, 20 chains the 20-40ths or one-half of the quarter section line; and so of any other number of chains that may be contained in the calls, they are so many fortieth parts of the whole length. And if, when required to run any certain number of chains on these lines, we find, upon measuring the whole length of the quarter section, that our measurement does not agree with the government returned lengths, we must bring our chain to the government standard by lengthening or shortening it, according as there may be an excess or deficiency, or, which in effect would be the same thing, apportion our loss or gain so as to correspond with the government measurements. For it is not the length of the standard chain at Washington, but of the chain that was used in the government survey of the line at the time it was run, that is the

standard by which we are to regulate our chain, and the length of that chain can only be determined by ascertaining the 1-40th part of the whole length of the quarter section line, or standard half mile. And so of any other measured government line. We must test our chain by, and make our measurements conform to, what is the legally declared true length of that line.

Hence, under this act of congress it plainly follows, that when a deed for a part of a section calls for certain courses, with distances in chains, without any other calls or qualifications, the distances must be according to the government chaining of that section; and that if any other than government chaining is intended, it must be so expressly stated in the calls of the deed; or what may be in effect the same thing, government chaining must be specially excluded. And thus I arrived at the conclusion that the lengths as well as the bearings of the government sections, and their regular subdivisions, as returned by the Surveyor General, are what must govern and determine course and distance as specified in the calls of the deed, when no monuments are named or qualifying or restraining words are used.

And so in relation to areas. The law is equally clear and conclusive. The act of May 18th, 1706, previously referred to, directed that the manner of subdividing townships should be into "sections containing as nearly as may be 640 acres each." The act of May 10th, 1800, provided that the sections and half sections bounded on the northern and western lines of the townships should be sold as containing only the quantity expressed in the returns and plats respectively, and all others as *containing* the *complete legal quantity* (viz.: 640 acres). The 2d section of the act of February 11th, 1805, provided: "that the boundaries and contents of the several sections, half sections and quarter sections of the public lands of the United States, shall be ascertained in conformity with the following *principles*, any act or acts to the contrary notwithstanding. The principle which controls areas is found in the 3d clause of said 2d section, and is that "each section or subdivision of section, the contents whereof shall have been or shall be returned by the Surveyor General, shall be held and considered as containing the *exact quantity* expressed in such return or returns; and the half sections and quarter sections, the contents whereof shall not have been thus returned, shall be held and considered as containing the half or quarter part, respectively, of the returned contents of the section of which they make a part. And the acts of April 24th, 1820, and of April 5th, 1832, provided for the subdivision of the quarter sections into half-quarter sections and quarter-quarter sections, and that the corners and *contents* should be ascertained in the manner and on the *principles* directed and prescribed by the 2d section of the act of February 11th, 1805." Now, as the contents of every section and quarter section was returned by the Surveyor General, and the land

was sold by the returns, the law attaches the same conclusive finality to these areas as returned that is given by the 1st and 2d clauses of said 2d section to the corners and boundary lines and their lengths; consequently it cannot be gainsaid or questioned that a section contains 640 acres, a quarter section 160 acres, a half-quarter section 80 acres, and a quarter-quarter section 40 acres. And so it follows that when a conveyance describes a part of a section as the northwest quarter of the southeast quarter of section &c., &c., containing 40 acres, it is unnecessary to add the restricting or qualifying words *more* or *less*, because by the law the quarter-quarter section contains that exact quantity, no more and no less. And as by the law 40 acres is the exact contents of a quarter-quarter section, it necessarily follows, that the reverse of the proposition is equally true, that 40 acres is a quarter-quarter section, and must be so held and considered when used in a deed of conveyance, unless some explanatory, qualifying or restrictive words are employed to change or modify the legal effect and application of the principle of said 3d clause. Thus the descriptive words of deeds often run, the east 80 acres of the southeast quarter, or the north 40 acres of the east half of the southeast quarter of section —, &c., &c., dividing the quarter section or the half-quarter sections by their declared legal areas; and in these cases the expressions, the east 80 and north 40 must be construed to mean the regular subdivisions of a half or quarter of a government quarter section, containing, as declared by the law, 160 acres; and are equivalent to the words, the east half of the southeast quarter, and the north half of the east half of the southeast quarter or northeast quarter of the southeast quarter. And this principle of area applies to all other subdivisions of the quarter section, such as the east 20 acres of the northeast quarter of the southeast quarter, or the south 10 acres of the east half of the northeast quarter of the southeast quarter of the section. And so of the various subdivisions of the quarter section by acres which can be made, and a clear, concise and accurate description can be given, analogous to the usual mode of division and description (by their relative positions) of the half-quarter and quarter-quarter sections.

And now, in conclusion, although the principles enunciated in the 2d section of the act of February 11th, 1805, for ascertaining the boundaries and contents of the sections, half sections and quarter sections of the public lands, may be entirely in conflict with our preconceived ideas of the law, appear unreasonable and unjust, yet as congress, having full and exclusive legislative authority in the matter, has seen proper by law to declare, in language not susceptible of misconstruction, that the corners marked and the boundary lines actually run and marked in the surveys returned by the Surveyor General should be established as the proper corners and boundary lines of the sections, half sections and quarter sections, and the lengths of such lines as returned, and the contents of each section or subdivision of section so returned, should be held and considered as

the true length and exact quantities expressed in such returns, there is left us no alternative or choice in the matter. We are bound to recognize the principles laid down in the law and conform our surveys to them. Yet a careful investigation of the acts of congress and a study of the history of the land litigation in the old states, will convince the most skeptical of the justice of these principles and the correctness of the conclusions deduced from them. For it was the evident object of the act of 1805 to determine, and as far as possible to forever settle, all controverted questions of boundary and contents in the public land system of the United States by declaring the corners established in the survey to be fixed and permanent beyond all question, the boundary lines as properly established in conformity with the cardinal points and unalterable, the lengths of such lines returned to be the true length, not to be denied or questioned, and the areas returned to be held and considered as the exact quantity beyond all controversy or doubt; and thereby not only avoid all claims or demands by individuals upon the government to correct any errors, conflicts, discrepancies or deficiencies in the corners, the location or length of the boundary lines of the surveys of the public lands, or the contents thereof, as returned by the Surveyor General, after the lands had been sold; and also any claim by the government to change or alter the same, or to make demand for any excess therein, or for any additional compensation therefor after said sale; but also to make this act a perpetual bar against all similar claims or demands by subsequent grantors and grantees. Thus eliminating from the surveys all those litigated questions of boundary and contents that had been the subject of long, tedious and expensive lawsuits, wrecking fortunes and creating family and neighborhood feuds that have made the land litigation of some of the old states historical.

DISCUSSION.

Mr. Gorden—The principles and conclusions of this paper are the same as I have used for years and I do not see how they can be gainsaid.

The clear and able discussion of the principles of law applying to the subdivision of sections under the laws of the United States by Mr. Enos places the whole brotherhood of surveyors under obligations to him; and a young surveyor by carefully perusing his essay and reading the laws referred to by him may acquire easily and in a short time a correct knowledge of the law in relation to subdivision of sections and parts thereof which cost the older members of the profession much time, anxious thought and perhaps mistakes which they afterwards regretted.

Mr. Stanford—In subdividing the section into quarters my prac-

tice is to run straight lines across the section from the quarter section corners on the exterior lines, and I would subdivide the quarter section in the same manner, that is by running lines straight across the quarter section from the middle point on each of the exterior lines. If I understand Mr. Enos' paper this practice conforms practically to his theory; but, I always put down the distances as measured by a standard steel tape, and if I compute the areas, at all I compute them from my measurements. I do not understand the law to require that every tract sold by the government for 160 acres shall always be sold for 160 acres, unless that is the correct measurement, except when sold by Government survey. In regard to setting off parts of government subdivisions from deed descriptions my practice is not uniform. If I can, I follow the understanding of the grantee at the time the deed was written. At one time where a deed called for thirty acres off the east side of a ¼ section, I measured off a strip thirty rods wide, though the quarter section was nearly 162 rods each way. At another time I measured off just one-fourth the length of an eighty or ½ quarter for twenty acres off the south end, though the north end of the eighty was nearly two rods the widest, and the south end less than 80 rods wide. Where the description calls for so many rods wide off the side of a Government subdivision, I think the line should be run parallel with that side, and I would understand the terms north, south, east or west to mean as that line was north and south or east and west without regard to an absolute north and south or east and west line.

Mr. Niles—The paper shows great experience and laborious research. Still, when the owner of a government subdivision succeeds the government, he becomes the sole proprietor of the subdivision, which contains an actual amount of real acres, and which he may dispose of as he will. How can an irregular tract be run out by the bearings found to apply to the section as left by the government, and what does it mean? Should it be the bearing or consequent variation of the nearest section line, or if in the middle, must it be an average of two or more bearings or of all of them? Two opposite section lines may, and do, differ from one to five degrees, and it is impossible to find the bearings of the section lines except separately, so that an average of all of them is the only variation to use. This won't work, for it is neither the bearing of the section lines nor the true bearing. The same objection applies to the chaining from the fact that the section all around shows no uniform de-

parture from government chains. We may, of course, establish all subdivisional corners under the pro rata system, when the bearings of the lines will take care of themselves; but when we come to meanders or slants, let us have the truth, giving carefully the variation used, and it, as near as possible, correct. The only reasonable way for a surveyor to describe the cut-off part is by true bearings and true chain.

Now as to descriptions; the east 80 acres of southeast quarter, and 80 acres off east side of same, mean precisely the same thing, and, government control having ceased, means and can mean nothing else but a conveyance of 80 acres, and a reservation of the balance. If I were requested to set off the east 20 acres, or 20 acres off east side of a sixteenth, I would proceed to do so, making the net area as near 20 acres as I knew how; but if ordered to apart the east half of the 40 I would do that. There may be of course a material difference between the east half of a 40 and a specified 20 acres off east side of it. If I had such a job on hand I would insist upon knowing what my patron means before I finished. So, in setting off any portion of land from a sole proprietorship, true bearings and true measurements are indispensible.

SUBDIVISION OF ANOMALOUS SECTIONS.

By HENRY C. NILES, of Tuscola.

In Hawes' "Manual of United States Surveying" on page 142 is a copy of a letter from Hon. Jas. Edmunds, com's, &c., dated June 11, 1866, which in the third instruction says: "All lines subdividing a section must be straight lines running through the section from the corner in one boundary to its corresponding corner in the opposite boundary of the section." The last two lines of the same letter are: "When the section corners have been established the section will be subdivided by running straight lines from corner to corner." Page 144 says: "All boundary lines of legal subdivisions, which shall not have been actually run and marked in the field,

shall be ascertained by running straight lines from the established corners to the opposite corresponding corners." And in same letter: "It will be seen from the foregoing, that the correct mode of dividing sections, is by running from $\frac{1}{4}$-post or corner to opposite $\frac{1}{4}$-post or corner, both north and south and east and west, the common center being determined by the intersection of the lines so run."

Here, and in several instances in said instructions, it might be inferred, by allusion to quarter-section corners, or posts, that regular sections only were to be treated of; but we find the injunction repeated almost indefinitely in various letters in which no reference is made to fractional or anomalous sections, so that the tyro at least, if not the experienced surveyor, would be fully justified in drawing the inference that these instructions apply to all sections alike, except, of course, those which are, from their situation with regard to meandered lines of water, or irregular Indian, or other reserve boundaries, truly fractional.

Such view is strengthened by the following from page 136 of same volume, the remark being without doubt the result of the author's deductions from these instructions. He says: "All subdivisional lines of a section must be straight lines running from the proper corner in one exterior line to its corresponding corner in the opposite boundary of the section." And he at once adds in very large small caps: "There is no exception to this rule."

Michigan Engineering Society in meeting of 1887 had in questions of practice a case orally presented by Mr. Skeels, a part of which was,—Query: "Shall each of these quarters (of sec. 6) be treated by itself, and independent of all beyond its own boundaries?" Mr. Pearsons read a letter from the Commissioner of the General Land Office dated September 2, 1876, the concluding portion of which says: "Except on the last half mile of the lines closing on the north and west boundary of a township, where they should be placed at 20 chains original measurement to the north or west of the $\frac{1}{4}$-section corners," signed J. A. Williamson, commissioner. Then the following resolution was passed with one dissenting voice:

"*Resolved*, That in subdividing sections, subquarter lines shall only be run across the quarter section they divide, and their terminal shall be points on the section or quarter section lines, at distances between the corners which determine them, proportional to the original measurements."

Mr. Skeels, dissenting, said he hoped the resolution would not be adopted, believing it contrary to United States laws; and in support of his position quoted the manual of J. H. Hawes, 1868, pp. 135, 136. He then called attention to the same instructions and opinions upon which this paper is based, including the Edmunds letters.

There are in practice two methods of subdividing north and west border sections, and one of these methods is popularly called the twenty-chain method, which consists in running off on the true

line twenty chains after twenty chains and setting off the plus or minus on and to the last lot, without any regard to the original length of the line as shown by the record. This we know is done and we know that in some parts of the state land owners submit to it. In town 25, N. R. 13 W. of 2d P. M. each of the north tier of sections is two and a half miles long north and south, each of the north quarters, (of Sec. 1 for instance), contains nine lots—eight of 80 acres each, and the ninth, a north lot, in each quarter, having more or less area. Here we happen to know that a local surveyor, a gentleman of long standing in the profession, pursued to the bitter end what he called the "twenty-chain method." That is to say, he began at the township section corner and ran north on the true line, setting a corner every 80 rods as he proceeded, and on arriving at the finish, very generously made a present of a deficit of 18 acres to the remaining or fractional lot No. 9. This was a northwest quarter, the average width of which was 40.60 chains, and the areas of the lots which he made 80 rods north and south, were each more than one acre in excess of the areas called for.

Now this friend proceeded upon the principle that the original survey record called for 80 rods north and south for every lot except the north one which was to have the residue; and he must have also assumed that he could reproduce precisely and infallibly the same chains reported by the original deputy surveyors. Had he first found the length of his chain as compared with the chain originally used, and acted accordingly, he would, in one sense at least, have found no excess or deficit.

And by the way—we all know it—but of all instructions given us by the powers that be, those requiring us to pro-rate our measurements, and thereby, as it were, force an agreement with the original chain, are the most rational; for, once understanding these, it makes no manner of difference whether your chain is a link too long or too short, so far as applies to restoring a lost government corner.

The above, one phase of the twenty-chain method, is mentioned incidentally as food for thought, but we do not do it the honor of admitting that it applies directly to the instructions sought to be objected to.

To return to the real subject: suppose a fractional $\frac{1}{4}$ section to be 44 chains east and west, and just 40 chains north and south, it would contain 176 acres. Now this area was in many, if not in most cases divided by computation into two lots; in this case Lot 1=80 acres and Lot 2=96 acres. In most cases, Lot 1 was sold by government as 80 acres and Lot 2 as the remainder of the $\frac{1}{4}$ section. We do know of cases wherein no lots have been shown on the plats; still Lots 1 and 2 were called for. Instances do occur where no lots are shown on the plat but the conveyance calls for the specified acres, as if there were lots. There are also many instances wherein the fractional quarter has been divided into quarter-quarters, the fractional area, but not the estimated chains, of which has been given.

Now it goes without saying that there may be a very material difference between Lot 1 of the N. W. ¼ and the south half of N. W. ¼. In these instances, where the area of each lot is given in acres and the dimensions of the quarter section as well, it would seem that in the total absence of chain dimensions for each lot the conveyances are clearly by the recorded areas, and it would be a case where areas are the controlling element. The areas are proportional by the record, and the chains are proportional by the rulings.

Instructions place the north corner of Lot 1 at 20 chains government measure from the quarter-section corner, and if carried out, would in this case give to Lot 1 88 acres, and to Lot 2 the same. Now of course it is impossible to draw a line 20 chains north of quarter-section line here and thereby set off a lot containing only 80 acres. It is much as if Government had said to the purchaser: "Your lot 1 contains 80 acres, but when the local surveyor cuts it out for you, he will, under the rulings, make it 88 acres;" and so in Lot 2 the purchaser gets, by the record, 96 acres, and only 88 by the instructions.

It has been stated by good surveyors that prior to 1842 none of the plats in the Surveyor General's office show any marked distances for the width of these lots: Nevertheless in many cases the contrary obtains.

Government always gives the areas, and in doing so, it is surely tantamount to instructions to preserve those areas, making the chains to suit.

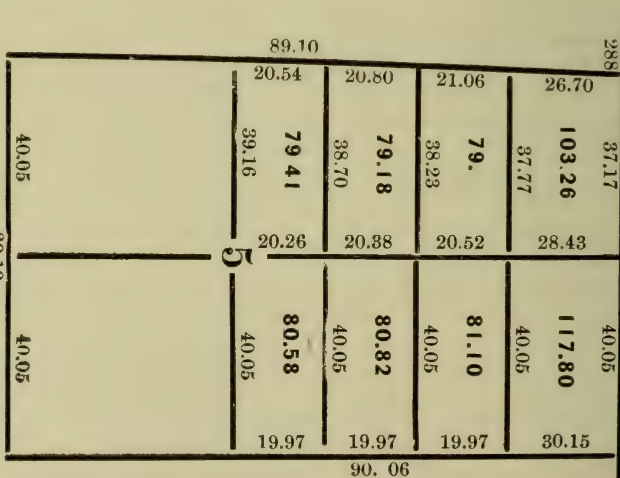


Fig. 1.

There is submitted here a diagram of Sec. 5, T. 5, R. 9 E. 3 P. M., and of others, either of which will perhaps answer for illustration, and everybody is respectfully asked to show how we can, by

any possible compliance with the instructions, make a legal, an equitable, or even a reasonable subdivision of the north half of these sections.

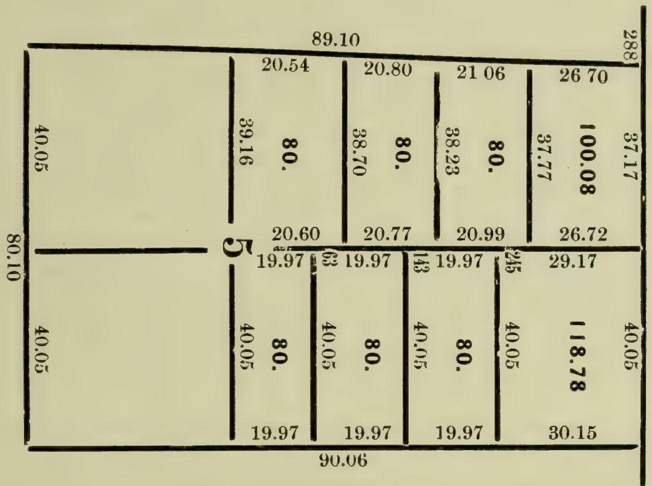


Fig. 2.

Here in fig. 1, which is drawn according to the instructions, it is seen that lots 1, 2 and 3 in N.E. quarter have an aggregate excess over record areas of 2.50 acres. Now if we add the excess here found in lots 1, 2 and 3 to the area in lot No. 4, we reduce the three lots to precisely 80 acres each and increase the value of lot 4 to the area given in the record. Be it remarked in passing, that the lengths of the east lines of these lots are actually given in the field notes. Referring to the northwest quarter, we find, by this instruction plan, that lots 1, 2 and 3 show a deficit in the aggregate of 2.41 acres, and that lot 4 is in excess just that much. Subtract this excess from lot 4 and apply it to lots 1, 2 and 3, we make each lot 80 acres even, and again we have field-note areas.

This is advanced in support of the claim that straight lines cannot be run from corner to corner across the section and preserve anything like the recorded acreage. It is probably conceded that when the section was originally surveyed the deputy reported only the four corners of the section, the four ¼-section corners, and the distances between them. This left well defined data from which to compute the actual area of each ¼-section. This of course was done in the office from the returns, and it was seen that the northwest quarter contained 340.92 acres, and that there would be more than the area of four 80-acre lots and less than the area of five, they then provided for three 80-acre lots, and a so called fractional lot of 100.92 acres. It was so set out in the office, and the task of actually laying them off was, and they doubtless thought, very safely, left to the intelli-

gent local surveyor. Moreover, we do find in some instances that the north and south dimensions of the lots in N. W. ¼ were really worked out and duly set forth in the field notes and to fit 80 acres. In all these estimates due regard was had for the varying east and west dimensions of the lots. It will be seen in this sample case that the west half of Sec. 5 has on its south line a width of 40.05 chains and on its north line the chains are only 37.17. Here we have a half section more than a mile long which from south to north has decreased in width 11.50 rods, and is it possible to here lay off three 80 acre lots and one of 100 acres, and find them of any thing like equal width north and south or east and west? Again, the east half of this section, and indeed of such sections generally, is of conformant width east and west throughout, being practically rectangular, and it follows that lots 1, 2 and 3 will also be rectangular, all of same dimensions every way, and that lot 4 is different only in north and south chains. If northwest quarter had been manageable to the same nicety of adjustment in the office, the treatment would have been the same, and in that case only could the instructions be followed. It then seems to follow that straight lines cannot be drawn from corner to corner and preserve areas, even approximately.

Again Sec. 6–15–7–E. 3d P. M. may be an exception to the rule, but if so, the rule itself gives no hint of it. Being Sec. 6 the east half is of course, 40 chains east and west, and consequently lots 1, 2 and 3 are each 20 and 40 chains and lot 4 same width but longer north and south. This is easy enough, but when we look at the northwest quarter of this section and make an attempt to follow the rule, we will have music wherever we go; for this northwest quarter has 5 lots, 4 of 80 each, and one of 109.

How can we run straight lines from lot corner in east line of this section to corresponding lot corner in west line? The lots are there, the rule is there, and the corners have no correspondence whatever, It is true that the instructions say: "Where no opposite corresponding corners have been or can be established, etc.," but the context shows that reference is had to water-courses, Indian boundaries, etc. We also know that the courts have settled that area is of the third and last importance in restoring lost corners, but they also say that, in the absence of monuments, or metes and bounds, area comes in. These are that kind of cases; for we see by the record that the ¼-section contained so many acres, and we know it is so for we have the figures, and we also know that there were so many 80 acre lots and also a fractional lot, and that the area of the ¼-section will admit of their being set out. Here then, are your metes and bounds, here, your monuments.

Shall we not first fix the exterior corners of the anomalous ¼-section independent of all other ¼-sections, taking care of course that first of all we establish the section center by a proper intersection of ¼-lines, and run it off according to areas, and, altogether independent of its fellow, find by actual measurement the present area of

the $\frac{1}{4}$-section, then adjust the chain to the original chain, run off 80-acre lot after 80-acre lot, finishing with the last lot, precisely as government did in the office, your fraction will come out just right, and there you are. Treat the fellow $\frac{1}{4}$-section in precisely the same manner, and as before, without any reference to its fellow except to preserve its rights as shown by the record. Then would we not have double corners on the $\frac{1}{4}$-section line between them? We would, and it does seem properly so.

Instructions to the contrary notwithstanding, it does appear that these corners on the $\frac{1}{4}$-section line cannot be common corners, and have the resultant separate areas anywhere near those found by the original survey; and, only in the event that the fractional section is a perfect rectangle divided into equal halves by a north and south line, can the corners on the quarter section line be identical.

If however, the instructions are iron-clad and we must submit, then and in that case the work of the local surveyor is much simplified, and in this regard they are a grand success.

DISCUSSION.

Mr. Lewis—Whenever a subdivision is to be made, each subdivision is to stand on its own merits.

Mr. Ela—My experience is that I have found it impossible to fit areas and lots to the plat without making different lot corners on the half section line.

Mr. Enos—When the government plat shows double points they must be made so, and if a single point then it must be made single. Where none are shown the law requires to make twenty chains.

Mr. Ela--Is not the law made for a different case?

Mr. Enos—I think not. The law of 1800 states the mode by which these fractional sections should be surveyed.

Mr. Loring—We have a case in our county where we have a jog of seven chains. That would work a hardship.

Mr. Enos—Each half section should be treated by itself.

Mr. Niles—The actual area on the field notes shows exact area as found by my survey. Divide them and give to each lot as shown by the area.

THE EXTERIOR BOUNDARY OF TOWNSHIPS.

By F. HODGMAN, of Climax, Mich.

The society has had presented before it pro and con the arguments relative to township boundary lines so fully that I do not feel at liberty to inflict on it very much in addition; still I feel that I ought to some extent express my dissent from the conclusions reached in the paper on that subject published in the proceedings of 1888. I do not wish to make a full and formal reply but to comment on a few points.

1st. We are told that the statutes regulating the surveys of the public lands are mandatory. From this we are led to believe that whatever the statute lays down must be so. If it says that "the public lands *shall be* divided by north and south lines run according to the *true meridian* and by others crossing them at right angles so as to form townships *six miles square*," that fixes the direction of the lines and the size of the township to a dead certainty. As a necessary corollary the writer would have us believe that if the deputy surveyor returns in his field notes that his closing line intersected the township boundary at a certain point and he set a post there, that it must be so even though the same notes furnish the evidence which proves conclusively on the ground that the post was planted forty rods more or less away from where he said it was. Such a mandatory pill is a little too large for me. I can't swallow it. No mandatory statute can make two contradictory things both true by saying they *shall be*.

2nd. We are told, "The issue is between the line of one survey as against the corner and line of another survey." Not so. The issue is between the line of the township boundary as run and marked on the ground by corner posts and such other visible marks, like blazed trees, as the circumstances permitted, as against the closing corner.

3rd. Again I quote: "That the lines from these intersection corners to the nearest section corners on the exterior survey, were actually compassed and chained is shown by the plats and notes of intersectional fallings." Not so. The point of intersection is indeed described but there is not a word in the notes to show how it was found. We may *infer* that the surveyor compassed and chained it. We may also infer that he guessed at it, which latter inference is likely to be nearer the truth in the case under discussion. Every other line is fully described in the field notes. The surveyor ran east on random, west on corrected line or north on true line as the case might be. But when he intersected the township boundary, not

a word is said about running a line anywhere, either from the closing corner or from the nearest section corner. Results are given and we are left to guess how they were arrived at The evidences point very strongly to the conclusion that some of them were guessed at. I have been surveying a great many years and have visited hundreds of these closing corners in the woods, and as a rule when I find the closing corner off the township line I also find the distance between corners falsely returned. Both line and distance were guessed at. Further; I never saw any but the closing line marked by the government surveyors from these closing corners. I doubt if anybody else ever did. At the very utmost it can only be claimed that the line was run one way from the closing corner. What about the other way? We are told that that line "which was not run or marked would by virtue of the concluding part of the 2nd clause of the 2nd section be legally established." Ah! and how, and where? "By running a straight line from the established corner to the opposite corresponding corner." Is there any doubt about this meaning the opposite corresponding corner in the same section? If not, let us see how it works. Take the instance cited in my former paper where the closing corner is returned in the field notes of the adjoining township as being 19 links too far north. The opposite corresponding corner to the east is say 24 links north of the township boundary as run and marked. According to directions we run a straight line between these two corresponding corners which shall be the north boundary of section 2. So this line which never was run or marked by the deputy U. S. surveyor or laid down in his field notes—never was approved or returned by the Surveyor General—this line which never had any existence outside the imagination is to supersede and override the line which was actually run and marked on the ground by a section corner, a quarter post and blazed trees—was laid down in the field notes and was returned and approved by the Surveyor General. It seems as though the very statement ought to show the fallacy of any such doctrine. I deny that any such imaginary line can overrule the real line actually run and marked on the ground, either in whole or in any part. I claim that the field notes do not show that any line was run to or from the closing corner for the township boundary, that no such line has been returned or approved by the Surveyor General—and that no such line can supersede one which has been run and returned and approved. I hold further that the closing corner as returned and approved by the Surveyor General is one in the township boundary, and if we find as a matter of fact on the ground, as proved by the corner posts and other marks, if any, of the township boundary as actually run and marked—that any closing corner was not actually placed in that boundary line where it was returned to be, it must be so placed before it has any legal value in determining that line.

I repeat. A line which was not run, marked, returned and approved by the Surveyor General cannot assert supremacy over one

that was run, marked, returned and approved by the Surveyor General. This goes to the root of the whole matter at issue. All outside of this tends to befog and hide the real question. I concede the truth of much that is laid down in the paper in the 1888 report and take issue with the writer on many other points, but do not deem it necessary to go into them here, as it would not tend to make my position any clearer.

THE IMPROVEMENT AND DEVELOPMENT OF EGGLESTON.

By GEO. K. WHEELOCK, of Normal Park.

In 1886 C. B. Eggleston, a capitalist of Chicago, bought and placed in the hands of R. E. Brownell & Co., a company of civil engineers and contractors, a tract of land containing eighty acres, lying in the N. E. ¼ of Sec. 28–38–14, for the purpose of converting it into a residence suburb, with all modern improvements. As engineer in charge, I will tell in the briefest manner possible how this was accomplished.

The subdivision was laid out into lots 50×130 feet, with 24 lots in a block. The streets were made to conform to those already in existence at the boundary and were of corresponding width. After the survey was made and all lot lines defined by a cedar post or stake, the work of improvement proper commenced.

The first thing to be considered was that of sewerage. The system used was the combined or single, owing to the present use of that system by the town of Lake, in which the property is located. A temporary outlet, by constructing a box-sewer 2×2 feet, was made, extending into low ground lying to the east, and indirectly connecting with Lake Michigan. North and south from this sewer, for a block either way, we laid vitrified pipe sewers 12 and 15 inches in diameter. The pipes were in 3-ft. lengths, and sealed with a ring and neat cement. At intervals of 50 feet were placed junctions or Y-branches for house drains, and at suitable distances branches for catch-basins. The manholes were placed 80 feet apart, and were of durable ring work and supplied with 7-inch wood covers.

To the branches were attached the house drains of 6-inch vitrified tile pipe, extending 3 feet inside of lot lines. The catch-basins were connected to the sewer by 9-inch pipes and were built back of the curb-line, then connected with street by cutting a hole through the curbing.

After finishing the sewerage system, the next duty was to furnish the proper water supply. This was done by placing an 8-inch water pipe in 72nd street, connecting with the city mains. Extending north and south from the main were laid 6-inch pipes for a block either way; to these pipes were connected the service pipes, which were of $\frac{3}{4}$-inch lead. At a point about 2 feet back of curb line was placed a shut-off rod and at the end a lawn sprinkler. At each three hundred feet, commencing at 71st street, was placed a fire-hydrant at a point 2 feet back of curb. To avoid "dead ends" all pipes were connected with old mains if possible, and when this could not be done, ends of such pipes were connected to each other.

The pipe used in this work was cast iron tarred, and tested to 300 pounds pressure to the square inch.

Following the water pipe came the gas. These mains ran in much the same manner as the water pipes did, but were not laid as deep and were laid on the opposite side of the street. These pipes were laid 8 feet east and north of the center of the street, while the water pipes were laid 8 feet west and south of that line. The size of the mains were 4 and 6 inches, of cast iron, not tarred. Service pipes were attached, one answering for two lots. Gas lamps were placed, five to each block, and of "the Chicago Boulevard" pattern.

After finishing the underground work, and properly back-filling all ditches and thoroughly setting the filling by flooding and ramming, we commenced the street improvements, which were to be done on the following conditions:

That the grading should be made to conform to grades given by the engineer, and to be thoroughly puddled or rolled, as might be thought best. Curb-stone to be of the best quality of limestone, straight, free from seams, cracks, sand-pockets, or other defects, and in sections not less than 4 feet long, $2\frac{1}{2}$ feet deep, and 4 inches thick when dressed. The top edge to be full and square and neatly bush-hammered. The face to be bush-hammered for a width of 9 inches from the top. The ends to be dressed so as to form close joints for at least 12 inches from the top. This stone to be set on blocks of stone, $6 \times 8 \times 12$ inches. At each street intersection the curb to be turned to meet the proper curb line of such (line) street, and the corner stones to be cut to a true circle of 10-ft. radius. The stone to be back-filled when necessary.

The requirements for the Macadam were: Upon the roadbed as graded and compacted, to be spread the best quality of broken limestone, broken so as to pass through a $2\frac{1}{2}$-inch ring, a quantity sufficient to form a layer 6 inches thick in the center, and 4 inches thick on the sides, after being wet and rolled with a roller of not less than 6 tons weight. Upon the bed thus formed to be spread a second layer of the same material 2 inches thick, and broken so as to pass through a one and one-half inch ring. Upon this second layer to be spread a layer of screenings 2 inches in thickness. The whole to be thoroughly compacted by a series of sprinklings and

rollings by a steam roller of not less than ten tons weight, until the same is firm and unyielding. All the above material to be free from dust, dirt, or other perishable substance.

At each street intersection cross-walks, to be constructed of two rows of flag-stones, said rows to be 14 inches apart and the stones to be 14 inches wide, by 5 inches thick, and 3 feet long, to be of same quality as curbing. The stones to be held in place at each end by a "header," $2 \times 3\frac{1}{2}$ feet by 5 inches.

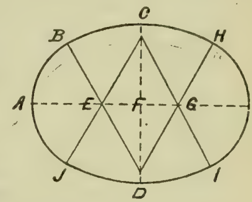
After finishing the street paving, walks were laid of dressed pine plank. The walks were 6 feet in width and placed with the inside line at a distance of 4 inches from the lot line, to allow for fence room, and on a grade of one inch in three feet rise from the curb line.

To add to the natural beauty of the place we planted a row of trees 20 feet apart on either side of all streets. At each street corner and middle of each block was placed a large flower vase and evergreen trees, the latter being trimmed in odd and fancy designs. The parkways were graded and seeded, and kept in a perfect state by a competent gardener.

RACE TRACK PROBLEM.

By D. H. DAVISON, of Minonk.

Required to lay out an oval race track whose length is L (40 Ch.) having radii r and R as m is to n (5 is to 11) and arcs in the ratio u to v (5 to 4). Express r and R in functions of L, m, n, u, v, and determine their numerical values, and distance x from center of oval figure to centers of the two arcs having radius r, and distance y from center of oval to centers of each of the two arcs having radius R. Also determine transverse diameter D and conjugate diameter d of the oval figure.



SOLUTION.

In the cut the points C and D should be at the centers of the large arcs instead of as indicated in cut.

Let $\varphi = BDC$, and $\omega = AEB$, $r = EB$, $R = DB$, $x = EF$, $y = DF$.

$$\varphi = \frac{90}{1 + \left(\frac{n}{m} \div \frac{v}{u}\right)} = \frac{90\,mv}{mv + nu} \ldots\ldots (1) \text{ and similarly } \omega = \frac{90\,nu}{mv + nu} \ldots. (2).$$

$$\text{Arc } AB = \frac{L}{4\left(1 + \frac{n}{v}\right)} = \frac{Lu}{4(u + v)} \ldots\ldots\ldots (3), \text{ similarly arc } BC = \frac{Lv}{4(u+v)} \ldots (4).$$

$$\text{Arc } AB = r\,\pi\,\frac{\omega}{180} \ldots\ldots\ldots (5),$$ or by substituting value of ω from (2) into (5) we have arc $AB = \dfrac{r\,\pi\,nu}{2(mv + nu)}$ ....(6). Equating (6) and (3) we find

$$r = \frac{L(mv + nu)}{2\,\pi\,n\,(u + v)} \ldots\ldots\ldots (7).$$ In a similar manner we find $R = \dfrac{L(mv + nu)}{2\,\pi\,m\,(u + v)}$, or $R = r\dfrac{n}{m}$ ....(8). It is evident that $x = r\left(\dfrac{n-m}{m}\right) \sin \varphi$ ....(9), and $y = r\left(\dfrac{n-m}{m}\right) \cos \varphi$ ....(10), also $D = 2\,(r + x)$ ....(11), and $d = 2\,(R - y)$ ....(12). Substituting numerical values of $L, m, n, u, v,$ in formulas (7) to (12) we find $r = 4.8229$, $R = 10.6103$, $x = 2.3540$, $y = 5.2871$, $D = 14.3536$, $d = 10.6464$. Having made the computations, lay out the track as follows: Take F for center of oval, and take distance x from F to E and from F to G, then take distance y from F to C and from F to D, making CD at right angles with EG. Now produce the lines DE to B, CE to J, DG to H, and CG to I, making each of these produced lines $= r$. Now with radius r from centers E and G describe the arcs BJ and HI; similarly with radius R from centers C and D produce the arcs JI and BH.

A METHOD OF CALCULATING AREA.

By S. T. ARMSTRONG, of Sycamore.

I enclose field notes of a survey made by me of a part of the old Burpee place north of DeKalb, together with a plat* of the same, the purpose being to show my practice. In selecting the base line for platting and of course for calculation, I intend to choose some point that may lie so that all ordinates may be plus, but in this no point could be so selected. I prefer the latitude ordinates should change signs, therefore I select an extreme east or west point and my double meridian distances have the same sign, and area changes with the northing and southing. The latitude and departure ordinates are the ordinates at end of the respective courses and the double meridian distance is the sum of any two consecutive departure ordinates, as the sum of the ordinates at each end must be twice the middle ordinate.

Course.	*Dis.*	*N.*	*S.*	*E.*	*W.*	*Lat. Ord.*	*Dep. Ord.*	*D.M.D.*	+ *Area.*	− *Area.*
S 46° 35′ E...	25.07½	.....	17.23	18.21	.....	0.0	.00	−18.21	313.76	......
S 46° 15′ W ..	21.01½	.....	14.53	.....	15.18	*−14 53	*15.18	−15.18	220.56	......
N 16° 22′ W..	15.40	14.78	.....	.....	4.34	+ .25	19.52	−34.70	......	512 87
N 89° 14′ W..	4.82	.06	.....	.....	4.82	.31	24 34	−43.86	......	2.85
N 16° 17′ W..	10 30	9.88	.....	.....	2.87	10.20	27.21	−51.55	......	509.31
N 89° 21′ W..	4.88	.06	.....	.....	4.88	10.25	32.09	−59 30	.. ...	3.26
N 7° 57′ E....	6 39	6.33	.....	.88	.....	16 58	31.21	−63 30	......	400.68
N 53° 33′ E...	2.32	1.38	.....	1.86	.....	17.96	29.35	−60.56	......	83.57
S 58° 50′ E...	1.90½	.....	.98	1.63	.....	16.98	27.72	−57.07	55.93	......
N 52° 51′ E...	6.81	4.11	.....	5.43	.....	21.09	22.29	−50.01	......	205.69
S 46° 35′ E...	5.62	.....	3.86	4.08	.....	17.23	18.21	−40.50	156.33	......
	....	36.60	36.60	32.09	32.09	....	......	....	......	......

Total − area = 1718.24
Total + area = 746 58

Double area = 971.66
Single area in acres = 48.58

Courses are determined from measurement of angles with a transit, the 1st course from N. and S. Section Line.

*Origin of co-ordinates are at beginning of this course.

Now to plat a survey, draw two indefinite lines at right angles to each other. A little practice will enable one to choose these lines so the plan will not run off the paper. If he will add together the greatest + Lat. ord. to greatest − Lat. ord. he will have the north and south dimensions, and similarly for the east and west. Then by means of triangle or parallel rules lay off N. and S. parallel lines

* The plat can not be reproduced here.

through these points, and with his scale set a point in each line at the proper distance, thus locating the corners.

This plan has this advantage over any other system known to me, because the natural tangent of any angle connecting any points in survey is easily determined, because one has means by which he can determine their differences in latitude and in departure, and therefore the natural tangent of angle with a N. and S. line.

This system is the brain work, so far as my knowledge goes, of James Matthewson, of San Francisco, Cal.,—at least he claimed it and was an able mathematician, the ablest by far that I ever had the pleasure of meeting. It is slightly modified to suit my own peculiarity so far as mode of planting survey is concerned. The idea of making a column of ordinates in the ordinary mode of tabling is his and is the kernel; if a mistake is made it relates only to the two lines joining that point in plat, and for speed beats the protractor out of sight.

DISCUSSION.

Prof. Baker—There are four independent methods of computing areas after having the latitudes and departures. The principles of these methods are explained in many trigonometries, and the method of applying them in both chain and compass or transit surveying is explained in Hodgman and Bellow's Manual of Land Surveying, and also in Johnson's Surveying. The method referred to in the communication before the society is simply one of these. I do not know to whom the credit should be given; but Prof. J. B. Davis, of Ann Arbor, in an article read some years ago before the Michigan Engineering Society, gave the credit for all four methods to the venerable Prof. J. B. Henck, of Boston. The common method of computing areas, *i. e.*, by latitudes and double meridian distances, appears to have been introduced by David Rittenhouse, of Pennsylvania, and is frequently called the Rittenhouse method and sometimes the Pennsylvania method. There have not been wanting in recent engineering literature instances of writers who have urged some one of these four as being much better than the Rittenhouse method; but as a matter of fact there is little, if any, difference between them. However, it is astonishing that the common method is usually so unskillfully applied. The man who plats with a protractor a field for which he must compute the latitudes and departures can hardly lay claim to being awake.

TOPICAL DISCUSSION.

It is the intention that this topical discussion shall give, without the formality and completeness of a set paper, the judgment, experience, opinion, or custom of the members upon the topic in question.

No. 1.

What, based on your experience, is the best routine system of superintending work?

S. A. Bullard, of Springfield.—As an introduction I will say that it is best for the superintendent to realize (1) that his drawings and specifications are so poorly stated or are so abstruse that only one who has been over exactly the kind of work specified can understand them without instructions. (2) That if he is intent on having his work done properly, he must thoroughly explain each detail and satisfy himself that the contractor does understand. For the contractor to say yes, yes, to your explanations is no sure sign that he understands you or the work. (3) That the failure of contractors and workmen to fully comprehend the drawings and specifications is a greater cause for mistakes, bad construction, and actual cheating in the progress of the work than any premeditated intention to perpetrate a swindle.

With these things in mind I go on the work fully informed myself so as to be able to explain anything that may arise as to the work. A note-book and pencil are good things to have, with a few loose slips of paper for making sketches.

I note on approach the materials on hand, amount, quality, manner of piling, and whether what will next be needed is provided.

I note the materials as they are being carried on the work, that the materials of certain quality are being used in the proper places.

I note that the dimensions are as shown by the drawings. I take nothing for granted, but measure things myself.

I examine the work being done by each individual workman and determine as nearly as possible whether he understands his business and whether he comprehends what is the work to be done. A word in a low tone to a workman in a kind yet authoritative way will correct erroneous ideas and make him strive to be right next time. I approve good workmanship in words that others can hear.

I pass over in my mind what work will be done before another visit, and give to the proper person any special instructions he may need if any. Do not fail in this.

In closing I can say that success in a superintendent is couched in these statements:

Explain and suggest to the owner.
Explain and insist to the contractor.
Explain and instruct to the workman.

J. O. Wright, of LaFayette, Ind.—There are two things necessary in the successful superintending engineer. The first is the entire *absence of obstinacy*,—of any desire to be officious, or fault finding, or domineering. The second is the presence of an unlimited supply of *backbone*, for use in securing the quality and quantity of work required in the contract. Having had experience both as engineer and contractor, I can appreciate the value of both of these items.

No. 2.

What theory in regard to the size of drainage pipe does your experience approve? Should they be large or should they be small enough to be easily flushed out?

D. J. Stanford, of Chatsworth.—In the construction of ditches for drainage purposes I would think best to use pipes small enough to be flushed with every heavy rain, both for the purpose of clearing silt out of the tile and as a matter of economy. Drain pipes may run full for twelve hours at a time without ordinarily doing injury to growing crops; and it has been my custom to leave the surface of the ground in most cases in such shape that a large part of a flood could run off over the surface leaving but little more to be carried away by the drain pipes than was held by the soil when saturated.

No. 3.

Is it necessary to use double strength culvert pipe for culverts, or will ordinary sewer pipe be strong enough?

I. O. Baker, of Champaign.—According to experiments (not by the writer) made by bedding the lower half of the pipe in sand and applying a pressure *along a comparatively narrow area*, the average crushing strength of ordinary sewer pipe was 2,400 pounds per square foot of horizontal section, and for culvert pipe is 12,000 pounds per square foot If the pressure had been applied more nearly as in actual practice, the pipes would have borne considerably more. The first of the above results is equal to the weight of 24 feet or earth, and the second to that of 120 feet, although actual embankments of these heights would not give anything like the above pressure. The writer is making preparations for an extensive series of experiments on the strength of culvert and sewer pipes.

The only danger of vitrified pipes being crushed is from the expansive force of frost. There is a little difference between culverts and sewers in the exposure to frost; but no danger need be apprehended from this cause, *provided* the culverts are constructed so that the water is carried away from the lower end, since ordinary soft drain tile are not in the least injured by the expansion of the frost in the earth around them.

J. M. Healey, of Champaign.—In the construction of roads it has been common to use the vitrified glazed sewer pipe. It has often been laid without protection for the ends, and in many cases has resulted in total failure; the ends have been thrown up by the frosts, leaving a low place at the center for water to collect and freeze, which has invariably broken and ruined the pipe.

The question is, can vitrified glazed sewer pipe be used successfully for railroad culverts? And is the "double strength pipe" any better than the other? Is it any less liable to be broken by the frost?

On this part of the Illinois Central railroad, where it has been used only in a few cases, it has been a failure. The first case is where a 2-ft. pipe was laid in 1878 under the main track just south of Loda station. Special pains were taken to have it properly laid, to give it sufficient fall, and to have the ends protected from the frost as well as they could be, etc. The first two years it was watched carefully, and there being no breaks, it was supposed to be a success. It was not till after the extreme cold weather in the winter of '84 and '85 that two or three pieces were found broken, then the next winter (being very cold) more of the pieces were broken, and in '88, when it was renewed with iron pipe, all the pieces were found broken. The damage was done in midwinter, when the water was frozen as it was flowing through the pipe.

Another case is where an 18-inch vitrified glazed pipe was laid under the main track north of Champaign station in 1883. It was in the prairie where there was but little fall to the stream. There was 8 feet of earth over the pipe. Great care was taken to have it properly laid, so there would be a good outlet, and since that time the ditch has been kept well cleaned, and yet to-day nearly every piece of the pipe is broken.

Another case is where a 2-ft. glazed sewer pipe was laid in the City of Champaign for sewerage purpose on Main and Walnut streets in 1872. It has been a success in every respect, except that at the outlet eight or ten feet of the pipe has been broken by the frost. As far as could be seen, everything was done in laying the pipe that could be done to prevent its breaking. There was sufficient fall, and there was no water allowed to stand in the ditch at the outlet. The bottom part of the pipe was frozen and broken with the damp earth or clay under it.

It is possible that a pipe could be used successfully, through a railroad embankment, if the joints could be laid in cement and a bed of sand or gravel (with a good drainage) used under the pipe. If it cannot be kept from breaking in this way, it could not be depended upon in time of need.

We have not used any of the double-strength culvert pipe. Where there is not much pressure and no frost, the vitrified glazed pipe can be made to answer a very excellent purpose; but where there is frost, the pipe of single thickness is not safe and it is very doubtful if the double-strength pipe would be any better. I prefer cast-iron pipe.

S. F. Balcom, of Champaign.—The pipes in a culvert in the I. C. R. R. after removal were found to be sound except those immediately under the tracks and they were all broken. There was two feet of earth under the track.

Mr. Baker—There must be enough earth—at least three feet—for a cushion above.

E. A. Hill, of Cincinnati.—We used a good deal of culvert pipe on the I., D. & S. road. The durability of the pipe depends more in the manner of laying than anything else. If you have them bedded well the pipe will last well. I do not know of any cases of failure on account of crushing.

Mr. Rottman—We have Blackmer & Post's 2-ft. pipe in the water-works at LaSalle and they last well.

Mr. Stanford—I have heard objectsons to using single-strength pipes for culverts in wagon roads.

Mr. Tryon—The commissioners in McHenry county are using sewer pipe for highway culverts and find them satisfactory.

Mr. Gastman—The commissioners in our county find pipes very successful.

Mr. Balcom—If water stands in pipes the danger from frost is considerable. As to the amount of frost necessary to break a common pipe I have found that water 4 inches deep standing in a 2-ft. tile, froze and broke it.

Mr. Stanford—The cause of breakage is worthy of examination. Some that I took up once were broken into four pieces longitudinally. I had not time then to investigate. What is the cause?

Mr. Bell—An 18-inch sewer was laid here in Bloomington in November one year. The ground for filling trench was frozen when put in. As soon as all was done a hose was turned on and the trench flooded. The sewer failed to work and on removal for reconstruction it was found that every pipe was broken.

Mr. Loring—We have used a good many pipes in Decatur but have had no failures.

No. 4.

To what extent do you use the needle in surveying? What, if any, do you consider the advantages of the compass over the transit?

D. H. Davison, of Minonk.—In making subdivisions of government sections, after finding an original government corner, I would use the needle in order to get an approximate course to the next government corner. After reaching the first station I would continue the line exclusively by use of back and foresights, and in no case would it be safe to continue the line by use of the needle.

After finding corners in timber lands I would perpetuate them by taking bearings to witness trees by use of the needle, the vernier of the instrument being constantly adjusted to take true polar bearings.

The contour of small bodies of water and meanderings of creeks where great accuracy is not required may be determined by use of the needle.

The distance across a creek, or to any other inaccessible object can be readily determined by use of the needle, and unless extreme accuracy is required its use is more expeditious than by reading the angle from the circle of the transit.

In answer to the second query,—for surveying land the transit is preferable to the compass in every respect; but in mine surveying the telescope is very liable to become blurred by steam and smoke, it is difficult to read bearings on account of the fine graduation, the telescope is in the way of getting light to the readings, and the instrument often can not be set as low as is required in mines of 2½-ft.

veins. I have a compass with a 7-inch needle, the graduation and numbering being larger and more accessible than on the transit, and the sight lines can be turned on the flag lamp at any desired distance, much farther than is possible through a telescope without illumination. I can work more expeditiously with a compass in mine surveying and generally use it in preference to the transit,

D. L. Braucher, of Lincoln.—I use the needle almost constantly in ordinary land surveying, but when practicable I always keep a backsight or foresight as a check on the possibility of being led astray by the influence of local attractions. This may arise from any one of a thousand causes, the most common of which are, wire fencing, old stoves, old machines, old wagons and plows, harrows &c., &c., which are often thrown aside in fence corners and covered with weeds so that, unobserved and without a backsight as a check, the line may be seriously deflected from that indicated by the needle under normal conditions.

I prefer a compass for all work for which it is well adapted, for the reason that it is *lighter*, *cheaper and less liable* to damage by the many mishaps incident to field work. Gurley's Railroad Compass is very well adapted to a mixed practice. It measures angles to a single minute on the limb, independent of the needle. I had one fitted also with a telescope for ranging long lines. It is detachable and the combination is one which I have found very convenient.

H. C. Niles, of Tuscola.—I prefer the compass for running meander lines, as it is lighter and handier, but for all general work I will take the transit.

Mr. Ela—I would like to inquire of some one who relies on the compass, how to obtain a corner at a barbed wire fence?

Mr. Braucher—I would do as I would in taking the angle of a railroad; turn off 90 degrees and run my lines parallel at some distance from the fence.

[It was the opinion of most members that generally the needle should be used only in trial lines and for a check on a large error in reading.]

No. 5.

What is the method and rate of paying for surveys in your city work—per day, per lot, for grades set, &c.

J. K. Croswell, of Kankakee.—No established rule, although rate is based on time and character of work. Minimum price for city, $5 per day; for private parties, $6. For parts of a day—1st

hour $2, each additional hour $1.00. All expenses for help, &c., in addition. For surveys involving expert testimony, including time in court, minimum $8. I can see no justice in making rates per lot or lot line—as there is no uniformity in such surveys—one may require 30 minutes of time and no expense, another one two or more days time, with expenses for additional help, livery, &c.

F. Rottman, of La Salle.—In La Salle the fees (extra) for surveying lot lines are $1.00 per lot.

A. H. Bell, of Bloomington.—The price varies somewhat but generally it is three or four dollars per lot. That is moreover dependent on the work to be done.

G. F. Wightman, of Peoria.—Sidewalk grades in Peoria are given *gratis*, consequently we do not have time to do surveying.

Mr. Braucher—Does Mr. Wightman find that people lay sidewalks to grades given?

Mr. Wightman—The grade is established by ordinance, and they have to conform to it.

S. S. Greeley, of Chicago.—In Chicago the prices for lot lines for buildings vary from $10 to $100 or more. Additions laid out, 50 cents per lot. Large subdivisions, 25 cents per lot. A surveyor with two or three assistants, $25 per day. While these prices seem high, yet there is a question of damages resulting from errors which often seriously affects the income of the surveyor.

No. 6.

What is the proper thickness of cover-stones for box culverts for different spans and heights of embankment.

Prof. I. O. Baker, of Champaign.—The relation between the thickness of the cover (when of average sandstone) and the weight of the earth over it is given by the simple formula

$$T = 0.25\, S \sqrt{H} \qquad (1)$$

in which T is the thickness of the cover, in inches; S the span in feet; and H the height, in feet, of earth over the cover. For average quality limestones use 0.20 instead of 0.25 as in the formula. If the culvert is under a railroad, the relation between the thickness and weight of bank and train is given by the formula

$$T = 0.25\, S \sqrt{H + 5} \qquad (2)$$

However, the thickness of the cover stones does not depend alone upon the depth of the earth, the live load, and the span. In the *first* place, the pressure on the cover does not vary directly as the

depth of the earth above it. (*a*) The earth itself acts more or less as a beam to support part, at least, of the weight over the opening. (*b*) The prism of earth directly over the culvert will be partially supported by the adjacent soil; that is to say, the particles of earth directly above the culvert will act more or less as arches resting upon the earth at the sides of the culvert, thus partially relieving the cover stones. (*c*) The stones at the center of the culvert would be relieved of part of their load by an action, similar to that mentioned above, whereby the weight over the center of the culvert is transferred towards the ends. In the *second* place, the pressure due to the live load is transmitted downward in diverging lines. Hence the weight of the live load is distributed over so great an area as to make it inconsiderable. In the *third* place, the cover must be thick enough to resist the effect of frost as well as to support the earth and live load above it.

It is impossible to compute, even approximately, the effect of the preceding factors; but experience shows that the thickness is independent of the height of the embankment, *provided* there is sufficient earth over the cover to prevent serious shock,—say 3 feet for railroads and 1 to 2 feet for highways. The thickness employed on the railroads in states along the fortieth parallel of latitude is generally about as follows:

SPAN OF CULVERT.	THICKNESS OF COVER.
2 feet	10 inches.
3 feet	12 inches.
4 feet	15 inches.

On the Canadian Pacific R. R., the minimum thickness of cover stones for spans of 3 feet and over was 16 inches, and under 3 feet 14 inches.

W. D. Clark, of Springfield.—I oppose the use of stone covers for box culverts, for it is very treacherous, as stone lintels over wide openings in buildings demonstrate. In architectural construction the greatest care is required to secure the least possible weight on the center of the lintel, and if possible relieve the stone of any weight whatever except over the bearings. Stone over box culverts carry the weight of the embankment, and is in almost constant danger of breaking in the center, especially if the stone is not perfectly sound. A brick arch is less expensive in many localities, and if properly constructed is absolutely safe. I endorse Prof. Baker in his plea for brick construction, as I never would use stone unless absolutely compelled to.

Mr. Baker—Box culverts have an advantage over arch culverts, in that they can be cleaned out by lifting the cover off.

Mr. Braucher—What do you consider the limit of width.

Mr. Baker—Not more than four feet.

Mr. Braucher—As you would add height to the embankment the earth would act as an arch above.

Mr. Burnham—Does not the kind of rock make a difference. I have seen granite in spans eight or nine feet.

Mr. Baker—We do not have granite in Illinois.

No. 7.

What do you consider the best method of sewer ventilation?

J. K. Croswell, of Kankakee—I know of no better method of ventilating public sewers in streets and alleys than through manholes and if necessary through lampholes in addition. For house ventilation a few words will not cover the subject.

F. Rottman, of LaSalle.—I know of no better way than a high chimney at the highest point.

Mr Braucher—In case of a chimney is the draft always upwards?

Mr. Rottman—Yes, it is.

Mr. Bullard—Would you suggest a chimney for each sewer or one for many sewers?

Mr. Rottman—One at the highest point of the sewers, and connect the sewers with it.

No. 8.

For short span highway bridges, which do you consider more economical, wooden superstructure and substructure or iron and stone, and what are the relative advantages of either?

J. H. Burnham, of Bloomington.—The economy of iron and stone, for both sub and superstructure, I consider as well established as the axioms of geometry in these days of engineering enlightenment, but I have never prepared a statement of this in proper shape to be used by a salesman, or to set forth in such a place as this. It has always been my own belief, however, that figures alone will not show the economy of iron over wood for these uses, but that the public money taken for modern iron highway bridges is larger in amount than under the old system, and their final economy must be figured out partly from their greater safety, partly in their requiring less frequent repairs with the loss of travel at such times, and partly from the better appearance of these improved structures. All these combinations added together appear to make the axiom self-evident.

Prof. Baker, of Champaign.—I am decidedly of the opinion that for short spans and at present prices wooden bridges are the more economical. A short time ago I had occasion to examine the bids for two 35-foot spans and found that the interest on the difference between the lowest bids for iron and wood would more than perpetually maintain wooden bridges. The data are not at hand; but if I remember rightly, I computed interest at 5 per cent. compounded annually, counted the life of a wooden bridge at 8 years, (for the truss it would be more than this), charged the iron bridge with a new floor at the end of 8 years, and found that the interest on the difference in cost would pay for two or three wooden bridges at the end of that time. This question is worthy of an extended discussion, and I recommend that we have one or more carefully prepared papers on this subject, for our next meeting. There are some points in connection with the present practice of letting contracts for highway bridges and in the law governing such matters also worthy careful consideration by this society.

No. 9.

The advantages and the disadvantages of the premium system for excellence in track work.

Discussion to include details and results of the various systems.

Edwin A. Hill, of Cincinnati—The premium usually offered is one month's pay to the foreman and men showing the best section at annual inspection. The award is based on the marks of judges who examine the line from a slowly moving train. On important roads having many divisions, the judges are often chosen from the Roadmasters and Division Superintendents. What I consider a better system is the one used on the Indianapolis, Decatur and Western Railway and which for several years has given excellent results, and is I think peculiar to that road. The section foremen judge each other, each marking on a scale of four on every section except his own. Allowance is made by the Roadmaster for extra time and force as taken from the Time Rolls of the various sections, all being thus placed on an equality.

The annual inspection trip is thus made a powerful educator of the foremen, and each year they are visibly spurred on to a generous rivalry with each other. The responsibility of judging of each other's work has a developing effect upon them. It makes them much more critical of their own work, and they are found to quickly appropriate points from each other and thus the system tends to unify their practice and towards a survival of the good, and an elimination of the things objectionable by what some would call a survival of the fittest. The inspection trips also do much to establish a true

esprit de corps among the men which is always a thing greatly to be desired.

I think the advantages all lie with the premium system; and while in theory a man for his regular wages ought to give as good service without as with the reward in view, and while the premium system involves, as some claim, the idea that faithful service must be purchased by extra pay, yet practically, as long as human nature is what it is, the value of the premium is repaid tenfold in quality and quantity of work rendered each successive year.

It is customary to accompany the announcement of the award with a printed summary showing the relative standing of the various sections, their improvement and vice versa; and on the I., D. & W. Ry. comments upon the work of the various foremen are added, those deserving of credit are praised and those needing it are gently admonished. Another idea peculiar to the I., D. & W. Ry is the diploma, neatly engrossed, signed by the President, Superintendent and Roadmaster, setting forth the award, the foreman's name, etc., framed and presented to the foreman with the premium, which serves as a lasting memorial and is kept by him as a thing to be proud of for all time.

The Pennsylvania Railroad, the Wabash Railway, the Plant system of Southern roads, and I presume many others have systems in successful operation, each differing more or less from the others in detail but all I believe having the enthusiastic support of those most familiar with them; and data on this subject are of practical interest to all in charge of track repairs. Most of the opposition comes I think from those least acquainted with the system and usually from those who have never tried it. For myself, having had three years practical experience with what I considered a very good form of it I go on record as heartily in its favor.

Chas. Hansel, of Springfield—We have adopted a system of premiums for the track work on the Wabash Ry. It is based on an examination by a special committee. An extra train with the committee goes over the road in November, taking eight or nine days for the trip. Each district is about 120 miles in extent. The issue of certificates is made about Christmas. We send a copy of the report to each foreman. The men take a good deal of pride in it. We think it economy. The system is rather intricate but I think we have good one. The following is an extract from the inspection rules:

RULES FOR ANNUAL INSPECTION OF TRACK.

1st. There will be an annual inspection in November, of each year, to be conducted by the general superintendent assisted by such officers as he may select.

2nd. The annual inspection shall determine the condition of each section and division of main track, and sidings, in the following particulars: (1) Line, (2) Surface, (3) Level, (4) Joints, Ties and Switches in main track, (5) Drainage,

(6) Policing, (7) Sidings (meaning all tracks outside of main track and must be inspected, marked and kept separately from markings on main track).

These conditions shall be determined by a system of marking, for every mile of road. 10 shall indicate perfection, 5 shall indicate condition unsafe for a speed of 25 miles per hour, and 0 the worst possible condition, and the intermediate numbers shall be used to represent intermediate conditions.

3rd. The annual report shall show the total expense for labor, for year, on each mile of main track and each mile of side tracks, the rating being determined as hereinafter set forth.

4th. The yard Sections 1, 17, 23, 37, 46, 113, 120, 215, 247 and 256, shall be classified together, for an award of a first and second premium, same as a district.

5th. The final rating of each section, for classification, shall be made as follows: The conditions noted under the head of Articles (1), (2), (3), (4), (5) and (6) of paragraph 2, shall be reduced to an average rating, which, in a column of the report, shall represent the general average for conditions noted on main track.

The general average of conditions noted under Article 7, in same paragraph, in its column, will indicate the general average of conditions noted on all sidings.

The average rating for expense will be calculated for main track and sidings separately. The general average for classification will then be the general average rating of condition, plus the general rating for expense on main track divided by two, and the general average rating of condition plus the rating of expense on sidings divided by two. The average of these last two results will be the rating of the section in every particular.

Sections having iron rail track shall be allowed one point over steel rail track, provided this difference does not increase the result above 10. This point will be added to final average and will not be noted by inspectors.

6th. The district showing the highest general average shall be rewarded by a premium of fifty dollars to the Roadmaster in charge. The second highest average on any district shall be rewarded by a premium of thirty dollars to the Roadmaster in charge.

7th. The section on each district showing the highest general average shall be rewarded by a premium of thirty dollars to the Section Foreman, and the second average by twenty dollars.

RULES FOR GUIDANCE OF INSPECTORS.

(1) *Line.*—The inspector will occupy a position vertically over the rail he is inspecting and will confine his attention to that rail. True line means straight line on tangents and uniform curvature on curves as far as the eye can detect. When these requirements are fulfilled the condition must be represented by 10. Continuous and very apparent deviations from the true alignment over the entire length of one mile, which would limit the maximum speed for safe passage of trains to 25 miles per hour, must be represented by 5. A condition of alignment which would be difficult for a train to pass should be recorded as 0. Conditions intermediate between these shall be indicated in the proper ratio representing these conditions.

(2) *Surface.*—The inspector must place himself as far on the opposite side of the car from the rail he is inspecting and as near the level of the track as possible, and must note only the rail farthest from him. True surface means a uniform grade line between changes of grades and the conditions must be noted as in preceding rule.

(3) *Level.*—The inspector must place himself near the center of the car; he must watch the level index, and must note unusual oscillations of the car due to unlevel track on tangents, want of uniformity of elevation on curves or unequal gauge. If the inspector can detect no vibration or oscillation of the car due to unlevel track, on tangents, and want of uniformity on elevation of curves, he will record the condition as 10.

(4) *Joints, Ties and Switches.*—A perfect joint is one that is fully bolted and tight. Ties must be properly spaced as per standard plan and shall be fully spiked, with four (4) spikes in each tie. Ends of ties on one side must be

parallel with rail. Switches must be placed exactly as shown in standard specifications. When these are fulfilled the condition must be represented by 10.

(5) *Drainage.*—Drainage of track will be divided into five sub-divisions, each of which is entitled, if in required condition, to a marking of 2. 1. Natural streams and surface ditches must be free from dirt and other obstructions. 2. Must be regular in direction and grade. 3. Parallel drains or side ditches in cuts must be shown as in standard plan, and at foot of embankments must be made with slopes one and one-half (1½) feet horizontal to one foot vertical; the inner edge of such ditches must not be nearer the center line of track than one and one-half times the height of embankment added to twelve feet. 4. They must be free from obstruction. 5. Ballast must conform to standard plan.

(6) *Policing.*—This subject will be divided into five sub-divisions, each of which, when in required condition, is entitled to a marking of 2. See specifications for standard section. 1. Cross ties and iron must be piled according to the general rules. 2. Grass, bushes and weeds should be kept cut close to the ground within limits of right of way, and not allowed to grow closer than within six feet of rails. Stumps and logs should be cleared from within limits of right of way. 3. Road crossings must be in accordance with standard plans, and must be clean and safe for the passage of animals and vehicles. 4. Signs must be placed in position as required in standard clearance diagram. 5. Cross and line fences shall be kept in repair after being constructed by fence gang. They shall be of standard plan. Cross fences and cattle guards shall be clear of all grass and weeds, and shall be white-washed.

Expense.—The section which is maintained at the least expense shall receive ten points. The amount of expense on each section to be determined as follows: From the aggregate expense of the year shall be deducted the cost of extra work, such as placing ties, rails, ballast and ditching, for which credit will be made as follows: Ties in rock ballast, credited at thirteen cents per tie. Ties in gravel and cinder ballast, credited at ten cents per tie. Ties in earth ballast, credited at eight cents per tie. Rock ballast, credited at two dollars per car. Gravel ballast, credited at one dollar per car. Cinder ballast, credited at one dollar per car. Rails laid, credited at one dollar per 100 feet. Ditching, credited at one dollar per 100 feet. After this deduction is made the section showing the least expense shall be marked 100. which, divided by ten will give the rating of that section. And for each additional $10 of expense over the lowest section, for all other sections, deduct 1 point from 100 points; the remainder after being divided by ten shall be the rating of that section regarding expenses on the general report, and shall be recorded as the average expense of all miles on that section.

The inspection committee shall consist of eleven men and shall be arranged as follows: Committee No. 1, two persons, Line. Committee No. 2, two persons, Surface. Committee No. 3, one person, Level. Committee No. 4, two persons, Joints, Ties, Switches in main track. Committee No. 5, two persons, Drainage and Policing. Committee No. 6, two persons, Sidings.

The placing of different members of general committee on the several sub-committees will be performed by the officer in charge of inspection. Each member of these committees will be furnished with a form showing the conditions which he must note, upon which he must indicate the rating of each mile.

The officer in charge of inspection shall take up all forms when rating has been placed thereon, and make a general report to the General Superintendent showing the rating of all sections as hereinbefore described, showing the names of all persons entitled to a premium.

The General Superintendent will then cause the awards to be made and have signs placed on sections to which premiums have been awarded, which will indicate the standing of that section on each sub-division.

CHAS. HANSEL, *Chief Engineer.*

Mr. Bullard—How long have you had the system in operation?

Mr. Hansel—We began in 1885. Other roads have different

systems but this plan is almost original, especially the expense account.

Mr. Balcom—Have you found any difference in the work rendered by young men and old men as section foremen? Who show up the best?

Mr. Hansel—That is somewhat difficult to decide. This is an age of progress. Our men are mostly young men. We do not dispense with men grown old in service.

Mr. Wright—I believe the Panhandle route has a good system.

Mr. Hansel—Yes, and the B. & O. road and others.

No. 10.

What is the cost of track laying?

Mr. Hansel.—I usually calculate a cost of $350 per mile for laying, while the total cost including ties and iron is nearly one dollar per foot.

Mr. Morse.—On a branch of the C., B. & Q. the contract was let at $300 per mile last year.

Mr. Cantine.—In western Kansas on a road on which I was assistant the estimated cost for laying new work was $500 including train crews.

A. N. Talbot.—Mr. M. H. Munson, Track Engineer on the A. T. & S. F. R. R. some time ago kindly furnished me with a detailed statement of the distribution of force and the cost for laying track at the rate of two miles per day as practiced on the A. T. & S. F. R. R. Ties were hauled by team, and the laying was done by the old-style method. On the Larned Branch 15 miles in 7 days were laid with this force—under favorable circumstances, however, very light grades, light work, roadbed in first-class condition, and light earth for ballast. On the Arkansas City Extension the main track laid in a month cost $292 per mile. I am of the opinion that track laid and surfaced, under ordinary conditions, for less than $350 per mile is cheaply done.

I may add that as the track laying was not contract work, care was taken to get first-class work, rails were not kinked by running over them before surfacing, and the surfacing gang left the track in excellent condition for new track.

The distribution and cost referred to is given on the following page.

COST OF TRACK LAYING.

Force for laying 2 miles per day:

No. of Men.	*Occupation.*	*Rate Per Day.*	*Am't.*
15	—Running iron car	$1 75	$26 25
2	—Unloading iron	1 75	3 50
24	—Spiking	1 75	42 00
8	—Strapping	1 75	14 00
5	—Spacing ties and "squaring" joints	1 75	8 75
4	—Lining track	1 75	7 00
7	—Setting "joint and center" ties	1 75	12 25
2	—Carrying gauges	1 75	3 50
2	—Distributing spikes	1 75	3 50
1	—Caring for tools	1 75	1 75
42	—Bedding ties	1 40	58 80
12	—" Nippers "	1 40	16 80
18	—Handling ties	1 40	25 20
2	—Stretching tie line	1 40	2 80
4	—Carrying water	1 40	5 60
1	—General foreman	3 33	3 33
1	—Foreman iron car	2 50	2 50
1	—Foreman tie-bedding	2 50	2 50
1	—Foreman handling ties	2 50	2 50
1	—Foreman track lining	2 50	2 50
1	—Foreman spiking gang	2 00	2 00
10	—Extra men	1 40	14 00
	22 teams hauling ties	3 50	77 00
	1 team hauling iron car	3 50	3 50
164	—Cost for labor only, of *laying* 2 miles of track		$341 53

Force for surfacing 2 miles of track per day:

No. of Men.	*Occupation.*	*Rate Per Day.*	*Amt.*
1	—Foreman	$2 50	$2 50
1	—Foreman raising track	2 00	2 00
2	—" Back bolters"	1 75	3 50
80	—Shovelers	1 40	112 00

SUMMARY.

84	—Cost, for labor only, of surfacing 2 miles of track	$120 00
	Cost, for labor only, of laying 2 miles of track	341 53
	Sup't of track laying	5 00
	Time keeper	3 00
	Train and engine crews	15 04
	Engineering	10 97
	Total cost for labor only of laying and surfacing 2 miles of track	$495 54
	Cost per mile	$247 77

No. 11.

What changes do you suggest in the present mining law?

Robert Winning, of Salem.—1. I would suggest that all men in charge of mines have a certificate of competency based on not less than ten years actual work in mines in some capacity, with a practical knowledge of those laws so essential to the safe and profitable working of mines.

2. Engineer in charge of engines to have a certificate of competency from a Board of Examiners, and the ages of engineer at such work limited to from 21 to 55 years.

3. That all parties or individuals before making new openings file statements with State Bureau of Labor Statistics at Springfield, and with County Recorder, setting forth the probable maximum number of men and animals to be employed therein, with dimensions of openings, the provisions for ventilation being such as gives one-third more air than required by law, to be submitted to and approved by inspectors.

The last part is put forth on the knowledge that there are three shafts in this district ranging from 600 ft. to near 900 ft. deep whose return air shafts were 6 ft. long to from 1 ft. 6 in. to 1 ft. 10 in. wide. The parties contracting for sinking the shafts told those investing that the sizes given were large enough.

Mr. Braucher.—We have a law requiring surveys to be made. I would suggest that the law be amended by placing a penalty for failure to fulfill it.

Mr. Balcom.—At or near DuQuoin are a number of old mines abandoned after being worked out, which might prove to be dangerous. Should not surveys of these mines when finished be on record?

Mr. Hansel.—At Decatur in working a shaft some material was taken out without a report or diagram of it. Our tracks (Wabash R. R.) settled by the hammering of the engines 18 inches or more. On being filled they would settle again. I could not explain it. I asked the coal company whose shaft was by the tracks for a plat of their mines. They promised it but for two years the plat has not been placed in my hands. I advocate a law making the keeping of a correct plat obligatory.

Mr. Davison.—The law requires that when a mine is about to be abandoned a plat shall be made and filed. The mining inspector can and should enforce the law.

A. C. Braucher.—When the work is ready to be abandoned, a part of the mine is already closed and impossible to reach.

Mr. Bullard.—A law as it now is has no penalty for disregarding it. It should be amended providing for such penalty and then it would be acceptable.

No. 12.

How far and under what circumstances will a corner or line ripen into title? See discussion on page 87 of last report.

D. J. Stanford, of Chatsworth.—Peaceable occupation for 20 years gives title. See Thomas vs. Sayles, 63 Ill. page 363. In 63 Ill. page 130, Sawyer vs. Cox, the court says that the line must be proved to be incorrect before plaintiff can recover.

Long established fence is better evidence of actual boundary settled by practical location than any survey made after the monuments have disappeared.

No. 13.

When (if ever) does a property owner acquire a prescriptive right to a portion of a street he may have illegally enclosed with premises under fence?

Mr. Bell.—No one can by possession acquire a right to property owned by a city.

Mr. Ela.—It seems to me that if the fence encroached on a public street in use title would not be gained by possession but if the street had been abandoned title could be acquired.

Mr. Niles.—A man came to me not a great while ago and asked what became of the street when abandoned by the municipality and I told him I thought it would go to the parties who owned the property adjoining the sides, but he showed me a supreme court decision that gave it to the original owner.

Mr. Braucher.—I surveyed a tract of land and platted it and the owner put his fence three or four feet inside the line. A lawyer who owns the ground adjoining claimed the land to the fence. Can it be just that a man loses title by leaving his land unfenced?

Mr. Lewis—If he pays his taxes he still owns it.

Mr. Ela—The Supreme Court in a Chicago case says that possession must be "notorious and hostile" in order to acquire title.

No. 14.

What are the minimum and maximum grades that should be established for brick or pipe sewers? Also for ordinary drain tile on the farm?

Mr. Braucher—Grade is established by a higher law and all we have to do is to use all we can get.

Mr. Neighbour—Mr. Braucher does not mention the minimum.

Mr. Braucher—If you have a level deepen it at the outlet or raise it at the upper end.

Mr. Elliott—The Twenty-second street sewer in Chicago is almost a dead level.

Mr. Greeley—Many Chicago sewers have a very small grade.

REPORT OF EXECUTIVE SECRETARY AND TREASURER.

To the President and Members of the Society:

The following is the report of the treasurer for the past year:

RECEIPTS.

Fees and Assessments	$176 00
Advertisements	271 00
Sale of Reports	16 50
Sale of cut	5 50
From G. P. Ela, former Treasurer	61 81
	$530 81

DISBURSEMENTS.

Printing Annual Report	$234 05
Electrotypes	26 03
Circulars and other printing	16 50
Express on Reports	14 85
Postage	51 10
Stationery	11 60
Incidentals	1 75
Blue prints	7 75
Salary of Executive Secretary	150 00
Balance in Treasury	17 18
	$530 81

A detailed report of the expenditures has been made to the Executive Board and may be seen by any one interested in it. The above report does not include money received by the former treasurer on dues for '88 and paid out on bills of the year before. Counting only the receipts from fees due before the last annual meeting and the bills presented at that time, the society was really in debt at the time of the last meeting to the amount of about $30, so that the above balance in the treasury is quite a gain on the preceding year.

1060 copies of the Third Annual Report were printed. The reports were printed by the Champaign Gazette at $1.25 per page, the bid of the Bloomington Pantagraph being $1.50. Copies were sent to the societies of Ohio, Michigan, Indiana, Missouri, Arkansas, the Dominion Land Surveyors and the Provincial Land Surveyors. The exchange copies of all these societies, except those of Missouri which have not been printed, have been mailed to the members. Any who failed to receive these should apply to the secretary.

The work of soliciting the large amount of advertisements, the revision and publication of the papers in the last report, and the numerous other duties of the office have taken an amount of time, labor and persistence not easily realized.

The society is in a healthy condition. A few have dropped mem-

bership by reason of removal, change of business, etc. The members are realizing the advantages of a connection with the society. The published papers contain many valuable items. The sales of reports last year included 14 states in the addresses of the purchasers. Our reports are everywhere favorably received. It is hoped that the membership will continue to increase, for there is room for it in each of the departments of the profession.

A. N. TALBOT, Executive Secretary and Treasurer.

REPORT OF EXECUTIVE BOARD.

To the President and Members of the Society:

Your Executive Board would respectfully report that we have examined the books and accounts of the Treasurer and find them to be in very satisfactory condition. We recommend that the rate of dues for all old members the coming year be fixed at $4.00 each and that for new members at $2.00 each.

A. H. BELL, Chairman.

REPORT OF LEGISLATIVE AND JUDICIARY COMMITTEE.

To the President and Members of the Society:

Your committee to whom was referred the question of legislation on inspection of highway bridges recommend that inasmuch as the supervision of the construction of highway bridges would require the services of many engineers owing to time required in passing from one to another, and whereas the people would be slow to entertain the spirit of such a movement, and whereas, there seems to be a unity of feeling among the masses to favor any law looking to the betterment of railroad bridges, it would be unwise at the present time to attempt to secure legislation, providing for inspection of highway bridges; but favor a petition to the legislature providing for the placing of a competent engineer on the Railroad and Warehouse Commission, whose duty it shall be to examine into the physical condition of the many railroads and confine his attention to this duty alone.

CHAS. HANSEL, Chairman.

REPORT OF COMMITTEE ON LAND DRAINAGE AND PUBLIC HIGHWAYS.

To the President and Members of the Society:

The following contribution is given by one of the members of the committee. The making and maintaining public highways in proper repair for general use in all kinds of weather and at all seasons of the year, is a problem that has not been very well settled up to the present time.

The problem requires very different kinds of treatment in different parts of the state. South of latitude 39½° the material for making roads is very good. The general soil is almost impervious to water, and a very common road grade kept well rounded and moderately high in the center, (so as to shed the water readily and cause it to flow off into the ditches on either side of it, and thence on to some general outlet,) will make as good a road as is needed or required by the public in general.

The section of the state lying between latitude 39½° and 41° has a very different soil. Instead of being impervious to water, it has a tendency to absorb the water and unless there is some under-drainage will retain it until evaporated. This section of the country is used mostly for the raising of corn and is known as the corn belt. The material used for roads when once put up into well-built grades with side ditches and a good outlet so that the water will not stand, makes a good road in dry weather. But roads of this kind are often impassable after heavy rains or when freezing through the night and thawing during the day occurs. Often farmers have hauled heavy loads to market early in the day, and in the afternoon have been compelled to leave their empty wagons by the road side and go home without them, on account of the light thawing out of the road grade during the day.

There is another tract of country lying north of latitude 41° that has a better material for making roads. The soil is naturally intermixed with sand and gravel, and in low lands where the soil is soft, the roads can be well covered with gravel or broken stone which is found in abundance throughout that section of the country.

In the town of Dwight, Livingston county there are some well-built road grades. The following plan of working the roads has been used there. The commissioners would decide which line of road in the town would be the most needed, and then one of them would visit the land owners along said line and get contributions to aid in doing the work. They con-

structed a good road grade with ditches on each side so as to carry away all water. They considered that standing water in the road ditches was the greatest detriment to good roads that they had to contend with. Each year their attention was given to certain lines of road, and one line was well completed before another was taken up. In this way they not only procured good roads for the town, but gave the land owners along the line of roads good outlets for drainage.

Another very practical way of making good roads is adopted by the town of Wheatland in Will county, and is carried out in the following manner: A common roadbed is thrown up, of a sufficient width for two common traveled tracks, and one side of this grade is prepared and covered with about five yards or loads of gravel to the rod. The estimated expense to the mile for making a good graveled track of that kind, allowing the teams $2.00 a day and the shovelers at the pit $1.25 a day, the haul to average 1¾ miles, is $760, or $2.38 per rod. This estimate was made by Mr. Frazer, one of the commissioners of highways of the town. The work was done by farmers in the winter time when they had but little else to do. Such a road as this can be used in all kinds of weather and at all seasons of the year. In making the road it is advisable to raise the gravel track above the earth track, so that in the winter seasons the snow will be more liable to remain on the earth track and more likely to blow off of the gravel track.

JOHN R. LEWIS, for the Committee.

DISCUSSION.

Mr. Burnham—Should not this Society in connection with the association of highway commissioners recommend a constitutional amendment whereby the assessment plan can be applied to country roads?

Mr. Tryon—I think we have road laws enough at present.

Mr. Lewis—Roads need a general supervision the year round. In such case a small injury to a road can be remedied at the proper time with little expense, while if it is let go till the usual period for road repair under the present system the injury would be so great as to require large expense and much time to repair it.

REPORT OF COMMITTEE ON LAND AND CITY SURVEYING.

To the President and Members of the Society:

Your committee beg leave to report a few contributions and to submit a few queries for discussion by the Society.

The question has often been asked me in city practice: "Why is it no two surveyors ever survey alike? That is if you were going to locate a town lot, no two of you would put the corners in the same place." In answer to this I generally say, "I don't know," because life is too short to go over the ground so often, and the ordinary mortal would not be any better off after an explicit explanation than he was before. Unlike the heathen Chinee we have no "ways that are dark or tricks that are vain." The surveyor's practice is a continual doing over what has been done before, in many instances without any knowledge of the original starting points and with modern instruments instead of those ancient relics of our forefathers. In making the survey of a farm or a town lot, we are nearly certain to find inconsistencies, which have to be accounted for and adjusted. Probably different surveyors would adopt different principles and methods in overcoming and adjusting these inconsistencies; just as the various physicians will differ in the treatment of a case in their profession. Then too, we now have the steel tape and the transit, where our forefathers carried the chain, or if he didn't have a chain he was a mighty good stepper. Another factor of variance that the surveyor meets very frequently in city work, is a surplus in actual measurements over recorded plats. I attribute this very largely to the fact that in the early days when these additions were laid out land was not of much value and distances were stretched a little in order to avoid controversy and to be sure that every lot got its full quota of ground.

Mr. Daniel McNabb, of Tonica, suggests that there should be further legislation to secure more specific, permanent and immovable monuments,—legislation that would require each surveyor who lays out an addition or surveys a farm to plant specific monuments, having a certain amount of uniformity and indestructibility, to be easily identified and not easily plowed out or removed. He also suggests that there should be legislation requiring surveyors, other than county surveyors, to file plats and reports of their surveys.

I believe there is much merit in both of these suggestions and they are referred to the members for discussion.

Mr. J. Withington, of Mattoon, suggests that in the case of

queries and questions of practice discussed by the members, a vote should be taken and the endorsement of the association made a matter of record.

Mr. D. L. Braucher, of Lincoln, submits the following suggestion: Some plan or system should be enacted whereby all the corners in the Public Land Surveys, established originally by the U. S. Deputy Surveyors, should be re-established and permanently marked by either state, county or township authority. It often occurs that we are called upon to survey a 10, 20 or 40 acre tract lying in a section that has not a single corner established and marked so that it may be identified.

This of course puts the surveyor to great trouble with inadequate pay; or the owner to great annoyance and expense quite out of proportion to the amount of work he wants done, or rather to the amount of land he wants located.

A. H. Bell, Chairman.

The vernier of the transit or compass used for surveying should be constantly so adjusted that the instrument will take true polar bearings. All lines of surveys when finally established should be described by their true polar bearings. This is the only truly scientific method of land surveying.

A survey made and described in this way may be reproduced at any future time with absolute certainty. The surveyor who makes the re-survey has only to be shown a true corner. He does not have to ascertain the variation of the needle at the time of the original survey, nor is he required to know the change of variation since the original survey. He has only to know that the original surveyor gave true polar bearings and that his instrument is adjusted to find those same true polar bearings.

A very usual method of describing bearings in reproducing government surveys is to say North variation so many degrees; the same with the east and west lines, changing the vernier on each different line to the variation of that particular line. Suppose it is required to re-survey these lines after a period of fifty years, we do not know what variation to give unless we know the change of variation since the previous survey. When we attempt to locate lost corners from the witness trees we find it is impossible to determine them accurately. This method of surveying is devoid of all system, the constant change of bearings leads to confusion, and is a fruitful source of litigation; it should be abandoned by all practical surveyors.

On the other hand the principle of describing lines and angles by true polar bearings will not subject them to change. The description of a deed made to-day by this method will be equally true fifty or one hundred years hence, and will not be affected by the change of variation.

Every practical surveyor should establish a true meridian line. A true meridian line should be permanently located at every county seat in the state, and all surveyors practicing in the county should be required to adjust their instruments to the line and make their descriptions of surveys conform to it.

D. H. DAVISON, Member of Committee.

[In the discussion following this, it was stated that in the description of lands by our rectangular system north means in the direction of the section line, etc.—unless otherwise stated—and that true polar bearings are not of such great general value as might be supposed.]

SUGGESTIONS TO THE COMMITTEE.

The original "laying off" of the great majority of town sites into blocks and lots, was in this region generally done in a superficial if not careless manner. The recorded monuments, if there were any actually placed, have been lost, and in the instances where they can be found, a measurement of any but a very short distance leads only to confusion.

In making an attempt to restore block corners there is, in the smaller cities, a very great degree of uncertainty. Built up blocks vary from one to six feet from recorded dimensions, and valuable buildings stand in the wrong place; and it often happens where front feet have become of a good price that a very few inches of discrepancy lead to law suits, and also to the discredit of the surveyor or engineer in charge.

Whether the corporation has the power or not to adopt certain poinst as standard, it is often done, and in many cases the effect is good, and is at the very least, tranquilizing.

Some 12 years ago my little city caused me to fix the center intersections of all streets, at which points I placed rather durable monuments. These were adopted by the city as standards, and it is comparatively easy to convince interested parties that they are right, and it *looks well* to be able to dig in the middle of a street intersection and unearth a corner; most people yield on seeing it. However, in many instances, it has been absolutely necessary to arbitrarily *adopt* certain corners of permanent buildings, as correct and true corners, it works well, but so much private surveying is done that discrepancies occur.

We find also that the opinion and work of an old surveyor familiar with all the facts go a great ways.

Just as soon as a city engineer finds himself under a decent salary, or indeed any salary whatever, he should keep such a careful

record of all his experiences that his work could be easily followed, and even if he has forced some conclusions, his work will be apt to stand and future generations will rise up and praise him.

While I have had no experience in large cities, I think that, when an established block varies from the recorded dimensions, the pro rata system should be used, keeping width of streets intact as far as possible.

H. C. NILES.

REPORT OF COMMITTEE ON MUNICIPAL ENGINEERING.

To the President and Members of the Society:

On account of the absence of one of the members of the committee in Europe and the amount of professional work on the hands of the other two members, the work of this committee has been necessarily somewhat neglected.

The most important part of the work has been done outside of the committee by Mr. Bell, of Bloomington, and by Mr. Alvord, of Lake View, whose able articles on Municipal Engineering in those cities will add value to our series on Municipal Engineering in Illinois.

The number of municipal improvements and the amount of expenditures for the same is increasing annually, and many failures and much needless expense point to the necessity of more practical information on these points and a comparison of practice and results in different cities. The present committee has during the last year been unable to accomplish much in this direction, but it is hoped that the next committee will be able to reach some tangible results.

D. W. MEAD, Chairman.

REPORT OF COMMITTEE ON EXHIBIT AND EXCHANGE OF DRAWINGS.

To the President and Members of the Society:

The committee have made a strong effort through both circulars to members and personal appeal to secure a creditable display of drawings and a collection of plans for exchange.

The large collection of drawings and views at this meeting shows our success in the first direction. Nearly a hundred drawings, plans, and views are on exhibition. These comprise plans of various

engineering structures, a variety that only an individual mention would describe, and quite suited to the diverse membership of our society. The value of this exhibit to the members is obvious. The committee ask that members continue in the good work another year,—that the exhibit may increase in value as the society grows older.

The condition of the exchange of drawings is not so encouraging. Although the committee has received a number of drawings for this exchange and has had the promise of many more, the number is not large enough to warrant issuing a list, and the society has not encouraged the work in the way it should.

Recognizing the value of this plan to the members, we recommend the continuation of the committee for another year and that the members be urged to help the collection by the donation of plans and drawings. Detailed plans of minor structures are as acceptable as those of larger undertakings.

For a detailed statement of the intended method of exchange, and the kind of drawings, etc. desired, members are referred to page 151 of the Report for 1888. Members are asked to read that committee report again. Proper support will make this a valuable feature of the society work. A. N. Talbot, Chairman.

NOTICE OF THE FIFTH ANNUAL MEETING.

The fifth annual meeting will be held in Peoria, Ill., the last week in January, 1890. The society has received a cordial invitation to visit that city, and a hearty welcome and a pleasant time have been promised the members. From an engineering point of view, the location is advantageous. The municipal engineering features will be attractive. The central location should insure a large attendance.

Besides the advantages of attendance at the meetings from knowledge gained through the papers and discussions, the social feature of the meetings, the acquaintance and contact with others in the same or similar work, the hints and methods and plans gained by a sentence from those who have met the same questions, as well as the general good time and good fellowship, go far to make these meetings extremely profitable. This was particularly true of the Bloomington meeting.

Members are asked to begin to prepare papers at the earliest opportunity. Jot down any item occurring in your work which will be of interest to the meeting.

The topical discussion is a valuable feature. In order to

increase its interest, members should send in such questions as they think suitable for further discussion.

It is intended that the scope of the society cover the work of city engineers, drainage engineers, surveyors, mining engineers, railroad engineers, etc. To this end, members in all lines of work are urged to assist in making the next programme attractive.

The exhibit of drawings will be a feature of the next meeting. A little exertion from each will add to the completeness and value of this.

MEMBERSHIP.

Applications for membership may be received at any time, thus allowing the applicant the advantage of the proceedings of the present year. Application blanks will be sent upon request.

NOTE.

The papers of Prof. Comstock, on the Use of Electricity in Mining, of S. S. Greeley on The Metric System, and of W. D. Clark on Specifications are withheld by the authors, and will be published in the next report.

ADVERTISEMENTS.

THE Society calls the attention of all readers to the advertisements which follow. Careful consideration will show that the firms are reliable and deserving of patronage. Members should show their appreciation of this generous support by consulting these firms.

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will be found on second page of cover.

REPORT

:OF THE:

FIFTH ANNUAL MEETING

:OF THE:

ILLINOIS SOCIETY

:OF:

ENGINEERS AND SURVEYORS,

:HELD AT:

PEORIA, ILL., JANUARY 29-31, 1890.

PRICE FIFTY CENTS.

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EDWD. W. LEE, PRINTER.

1890.

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208 S. 6th St., Springfield, Ill.

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Committee on Land and City Surveying—L. B. Neighbour, O. Jones, S. N. Howard.

General Committee on Engineering—E. A. Hill, I. O. Baker, E. L. Morse.

Committee on Mining Engineering—W. Rutledge, J. P. Williams, T. Hudson.

Committee on Municipal Engineering—J. W. Alvord, W. D. Clark, D. W. Maher.

Committee on Instruments, Blanks and Records—H. C. Niles, J. L. Clark, H. A. Stevens.

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Committee on Exhibits and Exchange of Drawings—S. F. Balcom, E. Philbrick, W. W. Able.

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—: OF THE :—

ILLINOIS SOCIETY ENGINEERS AND SURVEYORS,

1890.

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Frank V. Alkire..Petersburg.
Surveyor and Abstractor.

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Chief Engineer, Evansville & Terre Haute R. R.

*A. S. Aloe.............................300 N. 4th street, St. Louis, Mo.
Mathematical Instrument Maker.

John W. Alvord...............................69 Ashland Block, Chicago.
Civil Engineer.

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Professor of Civil Engineering, University of Illinois.

S. F. Balcom..Champaign.
Assistant Engineer, I. C. R. R.

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Civil Engineer.

Clarence Brainard..Buda.
Civil Engineer.

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Civil Engineer and Surveyor.

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G. M. Clark...........................Low Point, Woodford County.
Drainage Engineer.

*Associate Members.

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W. D. CLARK...Springfield.
Civil Engineer.

E. J. CHAMBERLAIN...Pitsfield.
Engineer Sny Island Levee.

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County Surveyor and Civil Engineer.

George V. Loring...Decatur.
County Surveyor and Civil Engineer.

T. S. McClanahan...Monmouth.
Surveyor and Civil Engineer.

D. McNabb...Tonica.
Surveyor.

Leonard A. McNeil...Spring Valley.
City Engineer and County Surveyor.

Daniel W. Maher..................................324 Burling St., Chicago.
Assistant Engineer, Dept. Public Works.

D. W. Mead...Rockford.
Civil Engineer and General Manager Rockford Construction Co.

Archibald Means...Peru.
Zinc Manufacturer.

John E. Miller...Monmouth.
Civil Engineer.

William E. Millar..Mattoon.
Civil Engineer.

E. L. Morse...Cazenovia.
Civil Engineer.

Jay C. Morse....................302 First National Bank Building, Chicago.
President Union Steel Co.

L. B. Neighbour...Dixon.
County Surveyor and Instructor in Civil Engineering in Northern Illinois Normal School.

H. C. Niles...Tuscola.
Surveyor and Civil Engineer.

James F. Parr.....................................Middlesborough, Ky.
Assistant Engineer American Association, Limited.

Ethan Philbrick...Western Springs.
Ass't Engineer C. B. & Q. R. R.

A. L. Richards...Quincy.
Assistant in U. S. Engineering Office.

Charles M. Rickard..Springfield.
City Engineer.

Emil Rudolph..............................50 Wisconsin street, Chicago.
Surveyor.

Walton Rutledge...Alton.
State Mine Inspector.

George F. Samuel...Chicago.
Ass't Eng., Dep't of Public Works.

A. C. SCHRADER........................3900 Cottage Grove Ave., Chicago.
Civil Engineer.

John H. SERVISS....................................Bonne Terre, Mo.
Chief Engineer Mississippi River & Bonne Terre R. R.

W. S. SHIELDS..............................69 Ashland Block, Chicago.
Civil Engineer and Surveyor.

L. N. SIZER..Champaign.
Drainage Engineer.

D. J. STANFORD..Chatsworth.
County Surveyor and Civil Engineer.

HUBERT A. STEVENS..........................145 Loomis street, Chicago.
Assistant Engineer, Department of Public Works.

A. N. TALBOT..Champaign.
Professor of Municipal Engineering.

LUTHER THOMPSON....................................Cherokee, Iowa.
Assistant Engineer I. C. R. R.

C. H. TRYON...Greenwood.
County Surveyor.

MILLS G. VORIS...Galesburg.
Civil Engineer.

GEO. K. WHEELOCK..Normal Park.
City Engineer.

E. H. WHITAKER...Box 729 LaSalle.
Drainage Engineer.

WHITMAN F. WHITE..Peoria.
Assistant in City Engineer's Office.

NOAH WHITLEY..Joliet.
Civil Engineer.

GEO. H. WHITTAKER..Pittsfield.
County Surveyor and Civil Engineer.

GEO. F. WIGHTMAN...Peoria.
City Engineer.

HERBERT B. WILLIAMS...Streator.
Mining Engineer C. W. & V. Coal Co.

JOEL P. WILLIAMS...Momence.
Civil Engineer.

ROBERT WINNING..Salem.
Surveyor.

J. WITHINGTON...Mattoon.
Surveyor.

J. O. WRIGHT...LaFayette, Ind.
Civil Engineer.

HONORARY MEMBERS.

F. HODGMAN...Climax, Mich.

EZRA D. SHREVE.......................................Bucyrus, Ohio.

FRED. J. SAGER......................................Columbus, Ohio.

Attention is called to the Sixth Annual Meeting to be held in Springfield, the last week in January, 1891, as given on page 157.

PROCEEDINGS

—OF THE—

FIFTH ANNUAL MEETING

—OF THE—

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS,

—HELD AT—

PEORIA, ILLINOIS, JANUARY 29, 30 and 31, 1890.

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JANUARY 29—WEDNESDAY—AFTERNOON SESSION.

The society met in the Council Chamber of the City Hall building of the City of Peoria.

The President called order at 2 o'clock and announced the opening of the Fifth Annual Meeting.

Executive Secretary Talbot presented his report as Secretary and Treasurer, and announced the death of three of our members during the year: Frederick Rottman of La Salle, Ill., George W. Richards of Carthage, New Mexico, and Henry T. Walsh of Buffalo, Ill.

On motion of Mr. Enos, the financial part of the report was referred to the executive board.

A list of applications for membership was read by the secretary.

Mr. Enos moved that all names be balloted on at one time and that unless a dissenting vote be cast, they all be declared elected. Carried.

The vote was taken and the following members were elected:

Mills G. Voris,	Galesburg, Ill
Albert L. Richards,	Quincy, Ill
Rudolphus R. Bourland,	Peoria, Ill
Leonard A. McNeil,	Spring Valley, Ill
William Edwin Millar,	Mattoon, Ill
John H. Serviss,	Bonne Terre, Mo

Herbert B. Williams, - - - - -	Streator, Ill
Joel P. Williams, - - - - - -	Momence, Ill
George C. Harvey, - - - - -	Mt. Carmel, Ill
Luther Thompson, - - - - -	Cherokee, Iowa
Wallace C. Evans, - - - - -	Watseka, Ill
John Edward Miller, - - - -	Monmouth, Ill

A verbal report was made by Prof. Baker, chairman of the general committee of engineering.

A report of the committee on exhibit and exchange of drawings was made by the Chairman, S. F. Balcom, stating that quite a collection of maps, tracings, blue prints and photographs had been received and would be displayed during the meeting.

On motion the society proceeded to the reading of papers.

The New Water Works of Peoria, by Mr. W. C. Hawley, was read by Mr. Bourland, and discussed by the members.

EVENING SESSION.

The meeting was called to order by President Elliott.

Hon. C. C. Clark, Mayor of Peoria, was introduced by Mr. Wightman and addressed the society as follows:

Gentlemen and members of the Illinois Society of Engineers and Surveyors:—So far as I am informed, this is the first meeting of your organization in the City of Peoria, and as its chief executive officer, it gives me much pleasure, on behalf of its people, to bid you a cordial welcome.

The tendency of the present age is undoubtedly to specialities in the professions, arts and sciences, in the hope, that thereby each will be more rapidly advanced in the line of usefulness and certainty, all for the good and enjoyment of mankind. You have adopted the line that has furnished the ideas and taken charge of the construction of all the great works—both public and private—of the present day: you have built our bridges, our tunnels, our railways, our pavements and many other structures, too numerous to mention. You have selected a most worthy speciality.

The object of these annual meetings of your association is for the purpose of advancing your special science and art; for the purpose of interchanging ideas, based upon experience in civil engineering, in order that the best means may be ascertained to render nature's materials useful to man. With each recurring session of your body, the skill of your profession will become broader and more perfect. We are all alike interested in its advancement.

I bespeak for you at this time a pleasant and profitable meeting. Our citizens feel honored with your presence, and I again repeat that you are most welcome.

Mr. Elliott, President of the society, responded to the Mayor's address, saying, that our previous meetings had been successful and the members had been much benefited by coming together and making acquaintances and exchanging thoughts. The reports of the society had been published and some of the papers had received extended notice, as for instance those on brick paving.

At the close of the President's remarks, the society voted that a copy of its reports be presented to Mayor Clark.

Secretary Talbot announced the President's annual address, the subject being, "The Engineer and His Work."

The paper by Mr. J. L. Clark on Public Roads, was read by Mr. Talbot. Discussion.

Mr. Bourland read his paper on Land Drainage, which was discussed, and Mr. Talbot read a paper by Mr. Hawks of Joliet, on, "A Proposed System of Sewerage for Joliet, Illinois." Discussion by the society.

THURSDAY—MORNING SESSION.

The society met as per the programme, with President Elliott in the chair.

The paper of Mr. Morse was taken up, read by him and discussed by the society—"Engineering Features of the Operating Department of Railroads."

Mr. Hill read his paper, "Short Curves," and after discussion, the paper of Mr. Burnham, "Iron Substructures for Highway Bridges," was read.

AFTERNOON SESSION.

The society visited in parties the principal places of interest in the city, guided and assisted by Mayor Clark of Peoria, and the local members of the society. Very much interest was taken by all in the electric street railway just completed, which runs to all principal parts of the city.

EVENING SESSION.

The society met at 7:30 o'clock.

The Executive Committee reported that they had examined the books and vouchers of the Executive Secretary and Treasurer, and found them correct and approved them. They found that the annual dues

would be the same as last year, four dollars for old members and two dollars for new members, in addition to their initiation fee. The report was approved.

The regular order of business was taken up.

Mr. Bullard read his paper, "The House for Health," after which the paper of Mr. Baker, which was laid over from the morning session—Notes on the Use of Cement Mortars—was read and discussed.

Mr. Davison's paper on The Elimination of Local Attraction in Mine Surveying, was next read. Discussion.

Mr. Balcom read a short paper, interspersed with verbal explanations of a large blue print plat of the bridge terminus referred to, on The Completion of the Cairo Bridge and the Terminal facilities at Mounds, which was generally discussed by the members.

The President announced the time for election of officers and called for the report of the Nominating Committee.

The committee reported:

Mr. President and Gentlemen of the Society—Your Committee on Nominations desire to report the following names for your consideration:

FOR PRESIDENT:

Z. A. Enos, - - - - - - - Springfield
S. S. Greeley, - - - - - - - Chicago

FOR VICE-PRESIDENT:

D. L. Braucher, - - - - - - - Lincoln
A. H. Bell, - - - - - - - Bloomington

FOR RECORDING SECRETARY:

S. F. Balcom, - - - - - - - Champaign
Charles Hansel, - - - - - - - Springfield

FOR EXECUTIVE SECRETARY:

S. A. Bullard, - - - - - - - Springfield

FOR EXECUTIVE BOARD, 3 TO ELECT:

Geo. F. Wightman, - - - - - - Peoria
H. C. Niles, - - - - - - - - Tuscola
D. J. Stanford, - - - - - - - Chatsworth
John W. Alvord, - - - - - - - Chicago
H. A. Stevens, - - - - - - - Chicago
D. W. Mead, - - - - - - - Rockford

Mr. Enos asked to be excused from the nomination for President, as he found it very irksome to attend to correspondence and asked the privilege of nominating Prof. Talbot of Champaign.

On balloting, the election resulted as follows:

President, - - - - - - -	A. N. Talbot
Vice-President, - - - - - - -	D. L. Braucher
Recording Secretary, - - - - - -	S. F. Balcom
Executive Secretary, - - - - - -	S. A. Bullard
Executive Board, - - - - -	Geo. F. Wightman. D. W. Mead, H. C. Niles.

FRIDAY—MORNING SESSION.

President Elliott called the meeting to order at 9:15 and announced the report of the Executive Board, recommending for membership, Mr. Chas. M. Rickard, City Engineer of Springfield, and Mr. W. F. White, Asst. City Engineer, Peoria, who on ballot, were duly elected.

The paper of Mr. Enos, The Consideration of a Law Compelling the Recording of Private Surveys was, at Mr. Enos' request, read by Mr. D. L. Braucher. Discussion.

Topic No. 8. What are the functions of surveyors in reference to plats and *re-subdivisions* of city lots as given by Chapter 109 and by Paragraphs 62 and 63 of Chapter 120, of Revised Statutes? was discussed, with Mr. Jones leading.

Topic No. 7 was then taken up. What is the best method of perpetuating corners which fall in graded roads? Mr. Loring of Decatur, and Mr. Whittaker of Pittsfield, lead in the discussion.

Mr. Hansel's paper on Interlocking Switches, was read by Mr. Bourland, in the absence of the writer, and discussed by the society.

AFTERNOON SESSION.

After re-assembling the President announced Topic No. 3, for discussion. What is the average length of life of ties on your road? At what cost will preserving treatment be economical?

Mr. Balcom, Chairman of the Committee on Exhibit of Drawings, reported on the drawings exhibited and made a short explanation of each drawing, so that each could be easily understood. Mr. Talbot expressed himself gratified at the exhibit of drawings and moved that a list of the drawings exhibited be printed in the annual report, which motion prevailed.

Mr. Colton's paper, The Alterations in the Washington Street Tunnel, Chicago, was read by Secretary Talbot, after which the paper of Mr. Davison, How to find a True Meridian? was read and discussed.

The paper by Mr. Stanforth on Topographical Surveying for Drainage Purposes, was read and discussed.

The discussion of Topic No. 6: "What comparison is there in efficiency and in cost in your vicinity between the two methods of maintaining country highways, 'working out' the tax and that of tax in cash and trained labor?" was followed by Topic No. 9: "In letting contracts, should the lowest bid always be accepted, and if not, what other feature should influence award of contract?" Also by Topic No. 10: "What is the ratio of municipal engineering expenses to the cost of work designed and supervised?" and by Topic No. 4: "What jurisdiction should the State exercise over railroads in reference to the prevention of accidents?"

Topic No. 12 was then taken up: "What rule for distributing tax should be followed in special assessments?"

Mr. Niles, the Chairman of the Committee on Land and City Surveying, asked leave to file a report with the Secretary for printing, which was allowed on motion.

Mr. Baker moved that the Executive Secretary be instructed to mention in the annual report, the fine display of instruments of A. S. Aloe & Co., of St. Louis. Adopted.

The Special Committee to report resolutions of respect for deceased members reported, which resolutions were, on motion, adopted.

Whereas, Since our last meeting, three of our fellow-members, Frederick Rottman, Geo. W. Richards and Henry T. Walch, have been taken from us by death, and

Whereas, The society has lost in the death of these members, able and efficient members, and the State honored and respected citizens, therefore,

Resolved, That we, as a society, tender our sincere sympathy to the families of the deceased, in their sad bereavement.

Resolved, That a copy of these resolutions be printed in the Journal of proceedings of this society and a copy sent to the bereaved families.

D. L. Braucher,
E. L. Morse, } Committee.

On motion of Mr. Hill, the thanks of the society were tendered to Mayor Clark of Peoria, and to the local members for their courtesy and efforts to make our stay in the city pleasant and beneficial, and Major Wightman was asked to convey to the Mayor this expression of our appreciation.

Mr. Enos moved that the Executive Board be instructed to determine upon a place for holding the next annual meeting and have it

published in the report. The motion was adopted under a suspension of the by-laws.

Mr. Braucher moved that the society express by a vote its high appreciation of the labors of the outgoing officers which was carried without a dissenting vote.

Mr. Elliott, the retiring President, after a few remarks, congratulatory on the condition of the society and its promising future, called the new President to the chair and formally presented him with the gavel.

No further business being before the society, the President declared the Fifth Annual Meeting adjourned.

S. A. Bullard, *Recording Secretary.*

PRESIDENT'S ADDRESS.

C. G. ELLIOTT, OF GILLMAN.

Members of the Illinois Society of Engineers and Surveyors:

GENTLEMEN:—We have for the present laid aside the transit, level and compass and have come together for a little recreation, not unmixed, we trust, with profit in this, the Fifth Annual Meeting of our Society. We have consigned our note-books, pens, and scales to their respective niches in the office, and are here to take a restful breath and to talk of the past, present and future of our profession—a broad field certainly—but one which we shall be able to touch in some of its departments to the profit and interest of all who are here assembled.

It is my pleasant duty to introduce this conference, an obligation imposed upon me by your votes at our last session, and certainly an honor when we consider the character of our society and the ability of its membership. I take this occasion of again thanking you for this, and all other favors and will say in passing, that it is easy, as well as pleasant, to talk to friends or to those who are engaged in like occupations with ourselves. It is a relief to feel that allusions to professional topics will be readily understood without a tedious and painstaking explanation of details which we have all doubtless experienced. It is to be hoped that we are prepared to relish the feast which our energetic secretary has outlined and to which we are all expected to contribute some inviting morsel.

We do not meet to-day an unbroken band. Since our last annual gathering, one of our members, Geo. W. Richards, a young and promising engineer, has been removed by death while in the faithful discharge of professional duties. Such losses to the society should serve to remind each of us of the power of the Divine Hand through whose favor we are permitted to exercise the function of life, and to control and direct a portion of the forces of nature for the good of the human race.

Our society is an organization within the State. It is natural that we should have a State pride in her material prosperity. The most of us are the sons of Illinois, either by adoption or birth. Many of us have received more or less training at her expense, and all of us have received her fostering care and protection.

While our membership is not limited by our State lines, nor our professional practice confined by her borders, yet it is true that our nearest and best interests are with those of the State which claims us as citizens to-day.

We stand upon historic ground. The river which lies at our feet, stretching like a thread of silver across our State, bordered by quiet hamlets and bustling cities, was made known to the world only two hundred years ago. At that time its waters carried only the canoe of the savage, and its unpolluted surface reflected the forms of a wild and untutored people. This broad expanse now bestudded with civilized homes and echoing the cheerful sound of industry was then, to the white man, a trackless wilderness. This unpretentious stream was the avenue by which discoverers reached the Father of Waters and penetrated this great west. It is but just that we, as engineers of this prosperous and happy State should accord honors of no mean kind to such explorers as La Salle, Tonti, and Marquette, whose dauntless courage, unswerving wills and natural genius for overcoming difficulties made known this fair and fertile land to an enterprising and progressive people. Such men always precede the engineer, and all forms of civilization. How slow is the world to recognize their achievements. Columbus died unloved and unhonored. The body of DeSoto lies beneath the waters of the Mississippi. La Salle perished by the hand of an assassin and his remains rest in an unmarked grave.

It is my purpose at this time to speak of the engineer and surveyor of Illinois, and his work, rather than of professional work at large, however inviting this last named theme may be.

The profession is one toward which many young men are turning their attention, some with a genuine love for the work, others under the delusion that it is a profitable avocation with the accompaniments of light work and simple duties. Possibly both classes are with us to-day. There are with us the older men of our society who surveyed on these broad prairies before some of us were born and have a fund of practical knowledge and experience which we all love to hear recounted. Honor to them, the pioneers of surveying practice, the forerunners of industry and accumulated wealth!

A question which is pertinent to each one of us is, What is demanded of us? and another, What is our professional outlook?

To answer these fully cannot, perhaps, be adequately done by any one individual, but I shall offer suggestions upon matters which, in my judgment, bear directly upon the success of each one of us in our professional career.

THE ENGINEER SHOULD LOVE HIS PROFESSION.

No matter how restricted his field of practice or how meager his supply of professional knowledge and experience, he should love his work. The most simple operation, either in the field or office, should possess an attraction for him. The application of pure mathematics to practice should be beautiful to him, even though the operation of making the application be hum-drum and common-place. Mud and water, rain and ice should not dampen or cool his love of the process by which a true result is obtained. He who sees only the theoretical truth of our fundamental formulas, and has no love for their application in practice, need not expect to be a good engineer. The engineer must do a great

deal of work for which the money remuneration is small. If he is so constituted that his delight in the work of itself is lacking, then his work is a burden and professional life dreary indeed.

THE ENGINEER SHOULD HONOR HIS PROFESSION.

He should do so by making himself as proficient as possible in the department to which he gives his attention. This is the bed-rock, so to speak upon which he must build his success. But proficient men do not always honor their calling. When the engineer does careless work because his best will cost more effort; when he charges his employer a fee for good work, when he knows that it is inferior; when he takes advantage of his employer or company to pass second grade work with a first grade name, he has joined the vast caravan whose members are beating their way through the world by paying less than one hundred cents on the dollar. When he accepts bribes from the contractor, and descends to the tricks of ordinary trade to increase his funds, he had better blot the name of his business from his card, and devote himself to a trade in which honorable dealing is not expected.

A leading lawyer of this State once remarked to me in commenting upon engineering and the law as professions: "I am glad that you are engaged in a profession in practice of which you can be honorable. In the law we are not." No young engineer should give any consideration to any inducements that may be offered to do any but simon pure, straight work. Such work, however simple, forms a part of his stock in trade, and cannot be dispensed with if permanent success is aimed at.

THE ENGINEER SHOULD BE A CLOSE OBSERVER.

The observation of a simple fact and the train of thought that may be induced by it, has led, and is continually leading to important results. The ability to map localities in the mind, and the observation of leading features of places and things are of very great value to the surveyor and engineer who is called upon to make plans for any public work. Straws always show which way the current runs. Observation combined with a sound knowledge of natural and mechanical laws, and a sufficient amount of boldness in the execution of work, are important elements of the successful engineer. This careful observation should be extended to men and their management, to sound business principles and forms, not omitting statute laws which have a bearing upon professional work.

THE ENGINEER'S POLICY.

What, then, should be the engineer's professional policy? After he has laid the foundation for a professional career as well as may be, and like the lawyer floats his card in the breeze, what should be his platform? He should keep in reserve a fund of knowledge and ability to use that knowledge, together with a certain amount of physical strength. There is an old saying like this: "Keep a thing seven years and you will have use for it." Some of our professional knowledge and training may remain unused longer than the proverbial seven years. I found myself called upon only recently to put in practice a bit of knowledge which I have not had occasion to use since school-days.

His habits should be methodical, and order should characterize all of his thought and work. It is one of the secrets of the successful management of all large and complicated interests as well as the common hum-drum affairs of life.

Courtesy of manner and address are not to be disregarded. We are men among men, and though patience may be somewhat taxed by what we may think are unnecessary questions, yet with a few exceptions, they should receive courteous attention. Like the ideal editor, the engineer should be always busy, yet always have leisure.

He should permit no careless work to go out of the office. While it is often not practicable to devote too much work to plats, statements, etc., yet all should be neat and adapted to the work for which they are designed. It is better, as a business principle, to give too much care to such work, than too little. The engineer should not permit his reputation to suffer because he is in a hurry, or because he thinks he is under-paid for office or field work. The practice of "making days" on work for which the *per diem* prescribed by law is too small, or the adding of "extras" of some kind to increase the final amount of the bill, is to be deprecated. We had better break loose from all political leading strings of this nature and stand upon individual and independent merit.

THE OUTLOOK.

As intimated in the opening of this paper, our work is principally within the State, and consists of various projects connected with ordinary internal improvements. Great railroads, great canals and great bridges, engage the attention of only a few and are often entirely wanting in the State, while the planning of water-works, town and house drainage, rural improvements in drainage and highways, street-car systems, town and country surveying, and city work is constantly demanded in all parts of the State. Such work is, in many respects, peculiar. It is expected sometimes, that the engineer, to a certain extent, should give free advice, when asked for. He should never volunteer it. That he aid somewhat in the molding of public opinion in regard to public progress and material improvements.

The improvement of wagon roads very properly continues to agitate the public mind. In the judgment of the writer, the end to work for, now is, the construction of hard roads along the leading thoroughfares of the State, each of them leading to some important town or market center. The improvement of highways which has been going on for several years, in the way of grading and draining, has prepared the bed in many places so that it is almost ready for a permanent covering of gravel or broken stone. The most difficult problem to solve is, the financial one, of properly providing funds for the work, and of determining upon what particular roads to so improve. And right here is a matter that should engage the attention of every Illinois engineer and surveyor, and that is, the schemes for proportioning and raising by tax, the funds for public improvements, such as highways, co-operative land drainage, streets, sewers, and all cases in which money is raised by

assessments upon property in the ratio in which it is supposed to be benefitted. Many complications arise in which equity and justice are involved, and which cannot be too carefully considered.

The County Surveyor's office seems to be in as unsatisfactory condition as ever, with respect to the law which governs it.

The only remedy the writer sees is, for surveyors to do as good work as possible, keep the records properly and charge a corresponding fee for the service. The surveyor must make good and thorough work, his basis of operation. If he can not do such work for the fee prescribed by the law, tell the patrons so plainly, and charge more.

On the whole, the outlook is encouraging, though not flattering. The value of good engineers is becoming better understood among the people of the State. Engineers are adapting themselves to the work that is demanded, and preparing themselves for the developments which experiment and science are continually opening up in this progressive age. Young men of ability and energy are asked to do important work in the several departments of our profession. Like other callings there is lively competition among the practitioners for the more lucrative work, so that close attention to business is necessary to success.

You will doubtless agree with me in the opinion that our profession is one that is elegant in the theory and principles involved, useful in the highest degree in its objects, healthful and ennobling in its practice, honorable as an avocation for any citizen of Illinois, and one of which we may be personally proud, no matter what department of it we may have named as our own.

The opportunities for becoming rich, are only moderate, such as can be expected in any business in which the principle of giving value received, is the rule in our deal with our fellowmen. There is no speculation, no building up of our financial condition upon fictitious values. We plan and execute work from which others reap the reward in comfort, riches and ease. We may justly congratulate ourselves upon being the guardians and promotors of those works which minister to the health and wealth of our fellow-citizens in this, our flourishing Illinois.

We may confidently expect that the proceedings of this, our fifth session, will take rank with those of our former meetings and mark a step forward in engineering practice among ourselves, and that as a result, the State at large may stand equal with our sister States in engineering progress.

IRON SUBSTRUCTURE FOR HIGHWAY BRIDGES.

J. H. BURNHAM, of Bloomington,

In the building of iron highway bridges in this State, it is unfortunately true that the element of cheapness is too often the leading feature. This is especially the case in townships and the smaller cities, there being but few places where the advanced ideas of first-class engineers have, as yet, become the ideas which prevail in construction.

One result of this, taken in connection with the scarcity of good stone for masonry foundations, has been to cause this State to be, as we may say, an experimental station for the various iron forms of bridge substructure which have offered advantages over wood, and proposed to take the place of masonry.

As I have been a pioneer in this State in the introduction of iron highway bridges, having contracted the first highway iron bridge in nearly fifty counties, and the first iron substructure in twenty-five counties, I have had opportunities for observation and am willing to bear witness to results.

These substructures may be divided into cast and wrought iron designs.

The first of the cast iron form were used in McLean, Sangamon, Champaign and other counties in 1867. These were the first iron substructures in the State, and, as I believe, the first west of Ohio. They were patented in this city Dec. 31, 1867, by Mr. A. B. Ives, the president of the Bloomington Manufacturing Company. Each corner of a superstructure, was supported by an A shaped pillar or column—divided at the bridge seat at an angle of about five degrees from the perpendicular. Each of the two legs of the column was cast separately, and flattened at the top, where they were connected by bolts. This casting had four flanges of the regular star iron shape. They were made heavy and were strong and durable, the best to resist rust of any style yet used. As a general thing they were placed on a timber foundation or mud-sill. It was not believed they could successfully meet masses of heavy ice, and they were seldom employed in rapid streams, and their history has been generally quite satisfactory. They were introduced into about a dozen different States, and did much to demonstrate the advantages of iron substructures in prairie or stoneless districts. Other forms soon came into use, much lighter and cheaper, one of the most common being some sort of an infringement on this, the oldest patent.

Among them may be mentioned Phœnix Column iron with the two legs placed exactly as those just described. Another style was composed of three I beams placed as a tripod, and in several instances four I beams were used as a tower.

These and other substructures used as piers, whether of cast or wrought iron, when well founded, when containing the right amount of metal, and not located in the way of heavy drift, have usually done good service, but there is quite a long record of failures of certain styles caused by ice or floating drift.

When used as abutments none of these plans have proved very satisfactory, it being impossible to sustain an embankment without the use of perishable material, or if assisted by any form of retaining wall of masonry, the cost is so near that of solid masonry, as to demonstrate the great difficulty of using any kind of iron abutments.

This very abutment difficulty was the origin of a patent about 1869, which was a design for a wrought iron frame-work for pier or abutment, which was covered with cast iron plates so as to resemble in shape an ordinary pier or an abutment.

Quite a large number of these were used in Indiana and a few in this and other States, but experience showed them inferior to masonry as against drift, while frost and "Father Time" soon demonstrated that the shell abutment was not a success.

At the present time we find a few cases where iron frames are used to support the bridge, while a thin wrought iron web-system sustains the embankment or grade. The comparative value of these devices can be estimated from the statement that if the thickness of the plates is three eighths of an inch or more, their cost will generally exceed that of good brick or rubble masonry.

A very good substitute for masonry is some times made of heavy angles, beams or Tees, so framed as to hold stone flagging to sustain the earth, but here again we are met by a cost nearly equal to the expense of good masonry.

I believe the Gray & Abbott Patent cast iron pile is a good substructure for a large class of cases. Wherever the bottom is tolerably firm and the height is not great, the length of these piles will admit of their being well driven, and if no drift is to be feared, this style will be found economical and durable. There is difficulty in using these where an abutment is a very essential element, and this, as well as other styles of iron substructure must be used with caution and good judgment.

Here again we find the pioneer patent in one line has led the way to others and there are now several other patent iron piles in the market proposing, as I suppose, to accomplish about the same result in a different manner.

When all the disadvantages of an iron substructure must be faced, as they must be in many cases, or no iron superstructure will be built, a very good style of bridge is the "End-Post," nick-named the Bed-Stead bridge. In this Truss there is no sloping batter or end-post. The top

chord is the full length of the span and the end post, made of heavy angles, Tees or of plates and channels, commencing at the extremities of the top chords, proceeds at once to the mud sills, so that its length is the depth of truss plus the height of the substructure below the truss.

An approach and abutment of wood is then constructed, its form suiting its exigencies of the occasion.

It will occur to many of you that I am omitting all mention of the different styles of iron trestles and also of the simplest form of iron bents so often used in viaduct work, and which for dry piers is perfection itself, but the styles and designs in use are now so numerous, that want of time prevents me from alluding to all of them.

The iron cylinder tube, filled with concrete, which is now, perhaps, the most used of any form of iron substructure for highway work, is probably the best in use. I will not state positively that this is the best. The difficulty of properly filling these with first-class concrete, the effect of frost on the riveting and the damage from rust at the ground line. are faults which time is bringing more plainly into notice, and it is highly probable we must make the admission that up to date, no entirely satisfactory method has yet been discovered for the construction of Iron Substructures for Iron Highway Bridges.

DISCUSSION.

Mr. Baker.—In regard to the filling of hollow or tubular iron piers with concrete, I would about as soon trust the concrete without the iron shell as the iron shell without the concrete.

Mr. Hill.—Why not then make a mould to form the concrete in, and on removal have simply the concrete pier?

Mr. Baker.—It would sustain the weight quite well if made of best materials.

Mr. Bullard.—Would a small concrete pier, even though strong enough to support the weight required of it be able to resist any lateral strain as ice or drift which might come against it?

Mr. Baker.—The pier would have to be made large in order to to resist that sort of pressure.

Mr. Hill.—Would it not be so large that its cost would be considerably more than the iron tube filled with concrete?

Mr. Burham. —Would not the large concrete cost as much as the stone pier and why not use the stone? The object of the iron substructure is to get a good successful substitute for the expensive stone pier in places where stone cannot be easily had.

PUBLIC ROADS.

J. L. CLARK, of Momence.

That our public roads are in a deplorable condition, no sane man will deny. That the loss to the country therefrom by obstructing its commerce, would, if it could be accurately ascertained, reach fabulous figures, is also an undeniable fact. That the difference between the assessed cost of maintenance of a road, every element of whose construction has been well taken, keeping it positively good at all seasons of the year (snow blockades excepted) and the extreme cost of present methods which, when all told, only result in dry weather roads, would in less than thirty years, and in many cases, half that time, amount to the actual cost of construction can also be easily demonstrated.

How to remedy this evil is the question before us. One of the most perplexing factors is the great variety of opinion as to what constitutes an ideal road and the manner of its construction. Every man has his opinion and all oppose, to a greater or less extent, any movement in the line of improvement which they cannot fully endorse.

It should be the duty of the man who has charge of the construction or maintenance of roads, to gather all the positive facts which are evolved in this war of opinion, learn what methods with certain conditions succeeded, and when conditions changed failed, and what other methods became necessary to meet the change of conditions, and he soon will have a fund of knowledge which will enable him to enter upon his work with all reasonable prospects of success.

Man's selfishness greatly hinders the work. A wealthy man told the writer not long since that it was for his interest to have bad roads, for with a market at his door he could market his produce during scarcity of supply, owing to the inability of the general public to move their produce, and by the side of his gains thereby, his petty losses from bad roads were nothing. Another man thinks the hard road benefits his neighbor more than him and so he opposes it, and so on *"ad infinitum."* A legislative act compelling the lands abutting on a good macadamized road to contribute towards its construction, such special contribution to be adjudged by a jury of six men, four of whom could render a verdict would do much toward eliminating that factor.

The topography of the country, area of water sheds nature of soil, material at hand, cost of construction and ability to meet it are all prominent factors, and the careful, intelligent man well needs to review his work before he thrusts upon the public the solution.

What constitutes a good road, and how is the best way to construct it? The first clause is easily answered. It is a smooth, hard, permanent road, with easy grades, and which no changes of season or weather can impair. So far every one assents the width of road-bed, amount of camber and manner of top dressing are open questions, and very intelligent people differ in opinion. The writer thinks that the bed should be thirty feet wide, having fully a foot camber, and if a stone top dressing is required, it should be twelve feet in the middle, leaving a dirt track on each side. If necessarily narrower, put the stone dressing at one side.

The answer to the latter clause is far more difficult. To attempt to lay down any fixed formula, is the sheerest nonsense. Different conditions require different methods, and the merchant who insists that all goods should be sold by the yard, whether it be muslin, music or molasses, silk, . sugar or sausage, appears not less ridiculous than he who maintains that there is one and only one method of construction. Drainage, both surface and subsoil is generally conceded to be the basic principle of road making, yet the old "Ridge Road" in western New York, the old-time beach of Lake Ontario, is always at its best during the wettest seasons. The exceptions are, however, too rare to form any valid objection to its general adoption. I believe that thorough drainage, which should include a marked improvement in the culverts, would, in many cases, far more than is generally believed, be all that is required.

Where roads are much used necessitating travel during long continued rains or when the frost is going out, to prevent their puddling, a top dressing of gravel, broken stone or some other hard substance is needed, varying from four to eighteen inches in thickness, according to the amount the road is used, and the nature of the underlying soil. These seem to me to be all the general rules to apply and their application is subject to nearly as many variations as there are rods of road to build. My answer to the latter clause then can only be, to put the construction under the supervision of a thoroughly competent man, one who can readily comprehend the nature of all the varied conditions which may arise, and has the ability to meet their necessities.

No great improvement in the roads of our State or at least in my part of it is yet visible and the argument is some times made that the building of so many railroads, thus doing away with the necessity of long hauls tends rather to dampen, than increase arder in the work, and that we are doomed to an eternity of bottomless roads. I hold no such pessimistic views. I believe the very genius of our institutions, social, industrial, political and religious, all conspire to make us a progressive people, a people who seize with iron grasp any marked improvement and earnestly press forward toward the more full and complete attainment. The signs of the times must, to the Bourbon, who desires no change, seem full of portent. Thoughtful men are considering the matter, engineers in its constructive phase, financiers in its economic, and the public generally in all the multitudinous phases towards which each

separate interest inclines. The anger aroused by its discussion is one of the most hopeful signs, for it proves conclusively that the masses have passed the barren ground of indifference and entered the fruitful field of earnestness.

Should we stand near the snow-clad Alps, we might for months look toward their frosted crest and note no change of scenery. Yet the quiet forces incessantly at work will, in the fulness of their time, with startling suddenness and resistless energy hurl the huge avalanche from summit to base. So we who have so long looked upon our road scene, whose fore-ground, back-ground, all, is bottomless mud, may confidently expect that the forces mentioned will soon ripen into systematic action. And when that hour shall strike, and the scenes be shifted with marvelous rapidity, I believe the dawn of a new century, now so close upon us, will be heralded by the brighter era. The old mud road will be buried in the dead past and risen in its stead the new road, clad in the habiliments of improved grades, culverts and bridges, armed with a coat of mail alike impervious to winter's frosts or summer's drenching storm and bearing upon its broad back the unobstructed commerce of the country. And, we taking our children out for a pleasure ride, speeding along at a 2:40 gait, grown garrulous with age, will relate the strange, yet o'er true tale of our mishaps, delays and vexations by flood and mud, and catch the expression of their upturned eyes so plainly indicative, either of their doubts of our sanity, or their determination to have our genealogy traced back in direct line to the veritable Baron Munchausen.

DISCUSSION.

Mr. Baker.—Improved roads cannot be secured by urging on farmers that they will "pay," but rather by taking the necessary steps to procure them where needed most.

Mr. Bourland.—Roads in the neighborhood of Peoria have been improved for a distance of some ten miles out, and the benefit is greatly felt.

Mr. E. H. Whitaker.—In the township in which I live (La Salle county) we have about 67 miles of roads. During the years '84, '85 and '86, there was expended an average of $1300 per year, or $19.40 per mile—a very small sum of money—and yet some of the tax-payers grumbled at that. That was the paltry amount of money we had to expend upon a tremendous stretch of roads. Necessarily, many miles had no attention whatever. The money was expended mostly on bridge and culvert repairs, and renewals and tile drainage.

We have less than a mile of gravel road in the township. One-half mile of this was constructed in this wise, viz.: The commissioners prepared the grade, and the gravel was put on by a contractor at $1.00

per rod. The contractor was a person very much interested in the particular road graveled, else he would never have taken the contract so low.

Tile drainage has done more for our roads than anything else, so far.

Mr. Talbot.—In DeKalb county, where a township has been working the past ten years under the tax system, and has, during that time, graveled the main roads, they have entirely metamorposed their condition, at a cost of only \$400 or \$500 per mile. Of course, the grading is not included in the amount. The gravel cost 50 cents a load in the pit, and the average haul was between three and four miles. This goes to illustrate the fact that localities having gravel within a reasonable distance may by a systematic method secure fairly good roads at a reasonable cost.

THE HOUSE FOR HEALTH.

BY S. A. BULLARD, OF SPRINGFIELD.

Pure air, pure water and pure food are necessary to good health. In man's early history these were not difficult to obtain. The first rude huts or tents erected for shelter had neither window nor door, and the zephyrs of summer and the blasts of winter swept through, giving to all the quantity and quality of air enjoyed by the birds and beasts. His hut was erected on the banks of the broad river, the murmuring brook or the bubbling spring, and from these he drank copiously. They satisfied his thirst, and without his suspicion of harm or injury. His food was the fruits of tree or vine, the cereal growing wild or with partial cultivation, or the wild game of the fields, woods and streams, which required both cunning and endurance to capture.

Not so the people of the present day. We shut ourselves up in tight houses, with doors and windows stripped with rubber so that not a breath of outside air may reach us. We drink water from wells, cisterns and hydrants, not knowing whence it comes nor what pure or poisonous fields it has traversed before reaching our lips. We eat meat placed before us by the butcher, not knowing whether it be from the best bred short-horn or from lumpy-jawed Texas cattle; also, mutton and pork.

So with our bread and pickles, and even with the children's candy. Like man, they are in many instances "fearfully and wonderfully made." While we may passionately regret the present condition of things, no one would go back to the primitive times of our fathers, and pitch his tent by the wooded streams, and, wrapped in his blanket of skins, sleep with his feet to the little chip fire. The "old oaken bucket" would lose all its poetic influence to the man drinking from a natural spring out of a bucket made from the skin of animals.

Since we cannot go back to those days if we would, and would not if we could, we must seek, as best we may, for a means of bringing to our use pure air, water and food, as nature in her infinite fullness has provided for us. If our houses are made air-tight, with windows and doors set in packing, there is no reason why abundant fresh air may not be brought in properly warmed and moistened and ready for use, nor why foul and vitiated air may not be renewed as easily and effectually.

There are three common means by which houses are made warm: By the ordinary stove or the open fire-place, in which cases the fire is made in the room where the heat is needed. This way makes ventilation sure, for a draught must be secured to carry off the products of combustion, the air for the support of combustion coming direct from the room. The outer air which must supply the place of that removed in the process of combustion usually comes in through crevices in floors and about doors and windows, the cold air in the room being constantly moved toward the fire. This movement of the cold air is unpleasant, and, in fact, unhealthy to occupants, and devices are used for overcoming it by supplying fresh air by special ducts from the outside to the place of combustion, all of which are good for the fire, but poor for ventilation. As the most important fires in the house are within the bodies of the residents, we should take more pains to procure fresh air for them than for the grate or stove, and as anxious to carry off their products of combustion.

A second means of warming is the use of the air furnace, which is simply a huge stove located in some convenient part of the house, and warm air from it conducted to the rooms in need of warmth. The movement of the air is dependent usually upon gravity. Warming by an air-furnace requires provisions for the removal of the air from the room, in order that the warmed air may be admitted, and thus makes the matter of ventilation co-ordinate with that of heating.

The third means of warming the house is by means of steam or hot water conducted into radiators in the rooms. These simply warm the air already in the rooms, and make no provision for ventilation. In order to secure that accommodation, air ducts are sometime provided, furnishing fresh air to the rooms through the radiators, but the direction and velocity of the wind have so much to do with the success of ventilation in this way that it is practically abandoned when good ventilation must be had.

The house in best sanitary condition is where a maximum volume of warm air is carried into the rooms, and ducts are in constant use for ven-

tilation. Thus the air is renewed at short intervals, as in summer when through open windows the pleasant breezes pass through the house.

For health it is required that the air should be pure, abundant and mildly warmed. Pure air can be had in abundance about almost any dwelling in a healthful district. Pipes of large capacity should be used that will carry a sufficient volume of air with slow movement. The warming of the air had best be done by a hot water heater in an air chamber and provision made for conducting the air from this chamber to the rooms. The temperature of the water in the coils in the air chamber may be regulated according to the temperature of the external air required to be heated, so that the same amount of air will be placed every hour in the rooms at a regular temperature.

Perhaps I may be better understood by an illustration. The water coil in the air-chamber is of sufficient capacity when the water in it is 170° Fahr., and the outer air 0°, that all air passing through it to the rooms will be heated to 85°. If the temperature falls to 5° below, then raising the water to 175° will still keep the moving air 85°. If it falls to 10° below, place water at 180°. If to 20° below, then water to 190°, and so on above or below zero. As the temperature of the weather changes, change the temperature of the water correspondingly, and the regular warmth of the rooms may be obtained. Water is best for this purpose, as the temperature may be much more easily maintained in the boiler than with steam. This method is the best in the world for the heating of school rooms and residences, where regularity of temperature is very necessary.

A variation of this system may be had by the coils of the air-chamber being placed in pairs, and made with cut-off valves. The temperature of the water being kept constant (200°), the different sections of the service-pipes could be cut off or added to the heating force, as the outer temperature required, to keep the air going to the rooms at a constant temperature. This could be made at a change of every 5°. By this system no register would ever have to be closed, temporarily stopping ventilation, and it would be better than the open fire-place, which is always adopted by the aggressive sanitarian, because no draughts of cold air are allowed in the rooms.

I speak thus about the warming and ventilation of the house, because the foulness of the air cannot be seen, nor otherwise be sensibly known. Bad water and poor food are more readily ascertained and the quality remedied, but there being nothing to show the air in a room to be impure, we are less inclined to believe it and make the changes necessary to correct the difficulty.

There are several things that combine to vitiate the air of the house and make ventilation a necessity. The chief source is with the beings themselves who enjoy its freshness and purity, and for whom the home and all its comforts are planned and constructed. Each individual is a moving stove, constantly giving off from his body the products of combustion, also filling the air with warmth and moisture. So far as effects are concerned, to have persons dwell in a house is the same as to con-

struct a charcoal fire in it, with a vessel of water constantly boiling above it. Other sources of contamination may be removed, and should be removed or alleviated, but this cannot, but must be provided for by ample ventilation.

The drainage of the house has its influence upon the air breathed by the inmates. If the plumbing is perfect, the air of the house remains as if there were no plumbing in the building at all. If the plumbing is bad, the air becomes infused with the gases arising from the drainage. Of all the effects pure air is subject to, the most injurious for health is the infusion of noxious gases from house drains. As a precautionary measure, the room with the principal plumbing apparatus should be well ventilated, if no other rooms in the house are ventilated. The injurious gases will then be carried off from the room instead of slowly finding their way into the adjoining appartments.

The different utensils connected with the plumbing of the house are the water-closet, which can be used as a urinal as well, the bath-tub, the wash-bowl, the kitchen sink and the laundry fixtures. All of these are usually connected with one pipe, known as the house drain, leading from the house to the sewer in the street. The street sewer is usually owned and built by the city or village, and where the combined system is used the city runs all the street water into the sewer at intervals along its course. It is made of size sufficient for this. With the house drain are connected the conductor pipes from the roofs, the waste from the well and the overflow from the cistern. It is best built of glazed socket-joint sewer-pipe, the joints laid in cement mortar, and made water-tight. Nothing inferior should be constructed.

The water-closet should be made entirely of earthenware, well glazed so as to be perfectly impervious to moisture. It should have as little wood as possible attached to it, and what it has should be hard wood, well finished with oil and varnish. The woodwork ordinarily seen enclosing the closet should not be used, but the closet left free and made so that any part may be reached with a cloth in the hand of a person, thus allowing easy cleaning. The whole closet must be so easy to clean and kept so that the ordinary housekeeper or servant girl will do it. If things are closed in, they will not be dusted nor cleaned by the ordinary servant, however dusty and foul they may become. The closet construction conveys the idea that the designer means the inclosure to keep dust and dirt out of sight, and in this instance the servant usually follows the supposed indications of the designer by hiding dirt instead of removing it. Have everything open so that air may circulate freely, and that dust and dirt may be easily removed, and so that if not removed it will look unkempt. To this end earthenware and woodwork should have few and insignificant mouldings, carvings, embossings or ornamentations in which dust or filth can lodge, be difficult of removal or be easily overlooked.

The closet should be a flush-out pattern, where the closet is automatically flushed out at the close of each service. The flushing should

be so strong and rapid as to carry all foul materials from the trap of the closet into the soil pipes, and away into the sewer, so that nothing may lodge in the pipes that would give rise to offensive gases.

I dislike traps, and believe that no trap should be in a pipe except right next to the take-in. The method of putting traps in the house-drain, somewhere between the street sewer and the house, is a very unwise one. The trap of a 6-inch, 8-inch or 12-inch drain is very large, and remains always full of the vilest filth which no ordinary amount of flushing will remove. The traps are so large that a small flush will not affect them at all, and, as a result, all grease, soap-suds and effete matter that will float stays at the house end of the trap to breed poisonous gases. If the trap were abandoned, the matter would immediately pass into the sewer, and be gone before noxious gases could begin to emanate from it.

It takes something like 36 hours for poisonous gases to arise from sewage, and if all sewage can be removed from drains and sewers in that time, no trouble need be feared from sewer gas. This probably explains the reason why you will find more foulness in a single house-drain trap than in the full length of an ordinary sewer. The sewers deliver their contents as rapidly as it enters, but the trap loves its reeking filthiness, and if cleaned time after time, will, like the sow that was washed, return to its vileness again.

The drain from the water closet should go direct to the sewer, without interruption, and with as few turns as possible, so as to reduce the liability to clogging.

The house drain to the sewer should be carefully ventilated, both between the street and the house and at the upper end, the end one being carried fully above the top of the house. The pipe should never be run into a chimney flue that has any pipe or fire-place openings into it from any room. It is only permissible in the furnace flue where it is used alone for the furnace draft.

If air can be kept passing through the drain pipes, then will they be kept free from disease germs. Ozone is the best friend of the sanitarian, and it will work for him uncomplainingly and effectually. It meets and conquers his unseen and unsuspected foes who undermine his house to effect an entrance, and work night and day for his downfall. Let us carefully assist this servant and friend by making the winding passages of our drains as easily of access as possible, and invite him to police their hidden depths that no harm may befall us.

By inducing the free passage of air through the drains we place them in a condition of least liability to permit foulness to enter the house. This is done by the gases being removed rapidly as formed, and being diluted by admixture of air, and by the air-destroying particles of matter that would result in the formation of gases were they to remain undestroyed.

The bath-tub is usually a wood box lined on the inside with copper and provided with warm and cold-water cocks, and waste and overflow openings. The box is supplied with a wood top of hard wood, and is

wainscoted plain or with panel work on side and ends exposed to view. The tub is thus so little exposed to the air that if dampness in any way gets under it, it is likely to remain. The safe and healthful tub is one that is exposed on all sides and underneath, so that it may be cleaned easily, and so that air may circulate all about it. Tubs of this kind are made of iron, white enameled inside, and ornamented with embossings of bronzed work on outside. They have also short iron or brass legs, lifting the tub clear of the floor about six inches. Around the upper edges or rim is fastened a narrow hardwood top or frame highly finished. This makes a neat and handsome-looking tub, and is clean and free from the accumulation of dampness, dirt or filth, and consequently is the best for health. The tub should be thoroughouly trapped from the soil pipe into which its wastes are run, and should be ventilated below the trap into the upper ventilator of the house drain.

The wash-bowl is but a diminuitive bath-tub, and should be treated accordingly. It should be open underneath—not closed in with wainscoting or panel work. Its wastes pass into the house drain, and the bowl must be thoroughly trapped from it, and ventilated below the trap into the main ventilator shaft, so as to prevent siphonage of the trap, and to make a means of affording the air a chance to pass through the pipes.

The pantry sink should be placed in a light place and supported on iron legs or brackets left open and exposed underneath, and be made as free from the accumulation of dirt and dust as any other piece of plumbing convenience in the house. It should be steel or iron covered with enamel inside and provided with strainer, water-trap and a grease-trap. A grease-trap should be provided; for no matter how strict instructions may be given the average kitchen help as to such matters, they will be constantly disregarded, and it is wiser to provide for such disregard than to subject the inmates of the house to danger to health arising from such carelessness. The grease-trap should be arranged to be cleaned easily, and only made large enough to insure the cooling and hardening of grease which enters the trap in a liquid state. All other matter should be carried off as rapidly as possible.

Laundry fixtures include tubs and slop-sink, which are usually fixed in the basement and near to the line of the house-drain. Laundry tubs are made singly or in nests, and are connected with a waste and overflow pipe to the drain. One trap may be used for the nest if they are close together. If tubs are separate, however, a trap should be used for each tub. This may seem expensive, but it is best. Each trap should be well ventilated. Water running through one pipe alwyas forces a displacement of the air in the pipe, and the more openings into the pipes the more thorough the displacement.

The slop-sink should be set in a convenient place in the laundry, and connected with the drain. It should be carefully guarded with a seive and trap, so that no large body could be forced into it, and no air from the sewer could escape into the room.

I have considerable faith in traps ; yet they are somewhat unreliable. The faith comes not so much because the object of faith is a worthy one, but from the want of a better thing to have faith in. There are a few objections to traps. The chief are that they are liable to syphonage, and are subject to have evaporation reduce the water in them to a position so low as to reduce the seal made by it. The syphonage can be overcome by thorough ventilation immediately below the trap. The reduction of the seal by evaporation can largely be controlled by the shape of the trap. If it be made with small pipe and the water very deep, the seal may remain unbroken for months before the limited amount of evaporation from it will make it worthless.

With thorough introduction into the pipes, of outside air, so that the products of the drain will be much diluted, with traps made small and deep, and with traps ventilated, so that syphonage is impossible, there will not be much danger from sewer gas, or vicious gases of other names.

By following patiently the work of warming and ventilating, the plumbing and attachments of the different rooms, as hinted in the foregoing pages, the householder may rest well assured that the best has been followed in making him secure against unseen and implacable foes who seek his life. And yet I would add a word of warning. You may have spent sums in the erection of your house ; yet it is susceptible to wear and decay, the action of storm and frost. You may have builded a well from which to draw the cooling water, but enemies may come unwatched and fill it with stones. You may have sowed good grain in your fields, and yet find tares growing in your harvest. So you may have been patient and faithful, and unstinted in your provisions for health, and comfort in your house, and then some day find disease stalking abroad, seeking a victim in your household. You must "watch, therefore, in all things," but you may rest assured that in so far as it can be made so by men, your house is the house for health.

ENGINEERING FEATURES OF THE OPERATING DEPARTMENT OF RAILROADS.

E. L. MORSE, of Cazenovia.

Engineering work in the operating or maintenance department of railroads, while similar, in some respects, to that of construction, differs from it, because the road-bed is built and established, the track laid and the road equipped, so that instead of having to deal with tangents and curves that may be exactly laid out, and the work made to conform, we find these already established, though very often far from being straight tangents or regular curves. Usually new work connected with the track will conform to the track as it is, but sometimes the engineer will have to adjust a tangent or curve that is out of alignment before he can proceed with connecting work. This more frequently occurs in yards than other places. In fact, the greater part of the track work the engineer will be called on to do will be in or connected with the yards. To get the greater amount of track in a limited space; to put in turn-outs, cut-offs and cross-overs, so as to give the greatest convenience in yard work; to change tracks so as to allow building or other improvements to be made, are some of the features that the engineer will meet with in track work. A good map of the yard, showing tracks and yard room, is of great assistance in work of this kind.

In adjusting curves that have become badly out of alignment, it is not often that they may be made of the same degree of curvature throughout, without requiring part of the track to be thrown too far from tho old road-bed. It has been my practice to fit the curve nearly as possible to the old road-bed, compounding, if necessary to do this, rather than change track and road-bed to any great extent.

A very bad and troublesome thing in a track is a crossing that is out of order. I refer to the crossing of two tracks. In square crossings, or where both tracks are tangent, the trouble is not so great, because not so difficult to keep the alignment, and hence easier kept in order than those where one or both tracks are curved, and the crossing at an acute angle. In the latter case the alignment is very apt to become bad, the frogs twisted and pounded out of shape by trains, and the crossing becomes unsafe. Then the only remedy is new frogs, made to fit the crossing, and carefully and well put in.

The measurement of new angles for new frogs for a crossing is a simple matter if both tracks are tangent. If both tracks are curved, and out of alignment, it is not so easy a matter, and requires some

careful work. I speak of this, because, from experience, I know that it is not a matter of a few minutes' work with the transit if good work is to be done and the frogs expected to fit; and this last condition is a necessity to have a good crossing. I think that a large part of the angle crossings is due to the fact that the frogs are not of the proper angle, rather than to their being badly put in. It would be tedious and uninteresting to go into details as to the methods used in measurement of angles for curve crossings, but will say it is a good plan to obtain the theoretical point of frog by means of the intersection of strings along the guage of the rails.

Too much attention cannot be given in making these crossings solid. The ties should be 8 by 10 inches sawed long enough to go under both tracks, firmly and evenly bedded. The frogs should be of the proper angles to properly fit their places, and then be firmly fastened there.

There are many other features of track work that comes before the engineer, as, the location of spur and passing tracks, turn-outs and curves, presenting some interesting problems at times.

Perhaps no other one feature is presented to the engineer in so many different forms, and so often, as foundations. From the bridge pier or abutment to a foundation for a small structure, and in all kinds of soil and with all kinds of materials does he have to deal. A great deal depends on the nature of the soil, as to what the character of the foundation should be, and, of course, a great deal on the structure itself, and the load there is to sustain; but for the same structure in different localities, and in different soils, it oftentimes requires something of a change in the foundation, not in the general plan, perhaps, but additions, it may be, to insure the safety of the structure. A soft clay will require some change in form of foundation or in preparation for the foundation than for a gravel or gravel and sand soil. Questions as to the character of the soil, the best form and material for foundation, and other features relating to the matter, are constantly coming before the engineer, and usually require his personal inspection and attention.

On good solid ground the subject of preparation for foundation is not a difficult one. Where the soil is wet clay, soft and yielding, or marshy and inclined to quicksand, it becomes a question sometimes of going deep enough to get solid ground, or to devise some means of getting a solid bearing surface. This may often be accomplished by going below the base of foundation, and filling in with gravel, thoroughly tamped and pounded till quite solid. A better plan, I think, if the soil will remain wet, is to use plank under the masonry, making the foundation pit larger than the intended masonry, so as to give a larger bearing surface, first having the bottom of the pit thoroughly tamped before putting the plank in place.

I lately had occasion to put plank under stone foundation piers for water tanks. The soil in these cases was wet clay, quite soft, and in rather low ground where it would not be likely to dry out. The piers were four feet in height, increased, in one case, to six feet to get a

greater depth, five feet square at base, and supported a load of about twenty tons. The pit was made six feet square, and prepared, as described, by tamping, and pounding the earth down solid, then putting in two layers of two-inch oak planks upon which the masonry was built. The same plan has been used under post foundations, and also under walls for buildings.

Earth should be filled and tamped around all masonry, and in the case of walls that have an earth pressure on one side only should be filled and tamped first next the wall and then away from it to lessen the danger of overthrow from the earth pressure.

Regarding the best kinds of mortars to be used, and the best proportions of lime, cement and sand to give the greatest strength and durability to masonry, there are others of the society who are better prepared to discuss these questions than I. In case of tank foundation cement mortar, one part Louisville cement to two parts sharp, clean sand was used.

If the engineer be employed on an old road running through this or adjoining States, he will very often find it necessary to go to the recorder's office to look up records in regard to disputed right of way. Roads lately built will not experience trouble in that direction, because land has become too valuable here to be parted with, without remuneration, and care taken in the conveyance, so that parties know exactly how much is conveyed, and lines carefully established. Formerly much of the right of way was donated in order to get the road constructed,—in some cases without any conveyance of title whatever, others only partially made, and lacking in description, making it a hard matter to retrace the lines, and in some cases impossible. In cases where a survey had been made and the surveyor's description given, there is usually no trouble, but some of the deed descriptions are totally incomprehensible, and, in fact, do not describe anything. One case in my experience, is, where the lawyer who had made the transfer was wholly unable to construe the description, and finally acknowledged the writing did not convey anything. This is sometimes very tedious work, and requires some experience before one can quickly look up records, but the experience is a good one for the engineer.

I have mentioned but a very few of the features of engineering work that will be met by the field engineer in the operating department of railroads, any one of which could be made the subject of an interesting article.

Other features of work, such as the drainage of structures and the road-bed, replacing wooden culvert, and short span pile or frame bridges by stone culverts or iron pipe, their bedding and protection, planning to some extent and selecting suitable location for all kinds of structures pertaining to a railroad, estimating time, labor and expense of different kinds of proposed works, and also to estimate material used and cost of work of new construction, either grading, foundation, or building.

If the engineer be in the office, he will find other and different features of work—usually elaborating and detailing plans, and building on paper what is afterward to be constructed in the field. A wide experience is obtained in this line of engineering—one that is very valuable to the engineer, and would be hard to get in any other way—certainly not on location or in the construction department.

DISCUSSION.

Mr. Balcom.—Should the operating department of railroads have charge of construction work; or, how can operation and construction be best provided for?

Mr. Hill.—Each road prefers a system of its own, but the best system is one with a general manager at the head, a chief engineer in charge of maintenance of way, a general superintendent in charge of transportation, and a superintendent of machinery in charge of motive power.

MINE SURVEYING.

D. H. DAVISON, of Minonk.

A method of effectually eliminating the errors caused by local attractions, while surveying in mines by use of the needle, and of determining all angles with as great accuracy as could be determined by use of the needle provided no local attraction existed.

Also a method of equalizing the true angular bearings, causing them to agree, as nearly as possible, with the surface surveys where it is presumed no local attractions exist.

In surveying mines we constantly meet with local attractions that deflect the needle to the right or left. The passways are laid with iron track, and we are generally obliged to set low; we often find piles of iron rails laid alongside of the track, near which we have to set; the frogs at intersections of entrys become strongly magnetized. In some mines we find iron or magnetic boulders that causes the needle when set near them to deflect several degrees. Yet all of these attractions have one property that allows us to counteract their pernicious influences. They are stationary. Hence, however greatly the needle may be drawn from its true course at any station, it remains the same while standing, and by taking a back-sight along the line we have run, and take the reading, then turn the sight-line to the flag-lamp, along the line we have

to run, and take its reading, the difference of these two bearings gives us the true angle of deflection of the line we are running, at the point where the instrument sits. This true angle is in no way affected by the local attraction acting on the needle at the time, which can be proved as follows: Suppose we were setting beside a pile of iron rails; we move the rails to the other side of the instrument, causing the needle to change its course—say, ten degrees. We again take a bearing to our back-sight and to our fore-sight, and find the difference between the two latter and the two former bearings are precisely the same.

On commencing the survey of an entry, we set our instrument directly over a chalk mark, and direct the flagman to set his sight-light on a chalk mark. After taking the bearing, we direct a chainman to leave his light on the mark until we take a back-sight to it. We then move forward to the sight-light, and, after taking the back sight, direct the chainmen to meausure up, and in the meantime take a bearing on the next fore-sight, continuing to take a backsight and fore-sight at each station. We set the figures indicating the back-sight directly under the bearings of fore-sight, but omit the letters of the back sight, unless one of them differs from the fore-sight.

We average, equalize and correct the bearings, at any time after the survey is made, as follows:

First, find all true angles of the lines by taking the difference between each back-sight and its following fore-sight. If the angle deflects to the right mark it R, and if to the left mark it L. These figures can be set partly between and a little to the left of the figures, whose difference they represent.

Second, find all average bearings by taking the half sum of the fore-sight and back-sight of each line. Set these bearings to the right of the original bearings in a column headed Av. B. It must not be inferred that we have determined the average bearings for the purpose of using them in platting our work. On the other hand, we have introduced this special example to show the utter absurdity of correcting our courses by averaging our back and fore-sight bearings. There is an angular deflection at every station, but if we depend on the absurd method of averaging our bearings for the purpose of platting our work, the plat in this case would show the whole of the lines seen as being one entire straight line.

Third, determine the true angular bearings, and place them to the right of corresponding average bearings in a column headed ∢ B. The first angular bearing can be taken same as the first average bearing. This bearing may be considered an assumed bearing, and as all other bearings in this column are based on this assumed bearing the whole column may be considered as assumed bearings. Any other bearing, either larger or smaller than our first assumed bearing, may be taken instead of it, and the final results, in every instance, will be perfectly the same. We find the second angular bearing by changing the first angular bearing to the right or left, as we first found the regular difference between the courses. The third angular bearing is determined by

considering the true angular difference between it and the preceding course, proceeding in like manner until all angular bearings are determined. We now have bearings that will truly show all the angles as they exist in the line surveyed, but in order to make these angular bearings agree with a general average of all the original bearings, we proceed as follows :

Fourth, make two columns to the right of column ∢B, headed R and L. Compare each angular bearing with each corresponding average bearing. If the regular bearing deflects to the right of the average bearing, put difference between them in column R, and when angular bearing deflects to the left of its corresponding average bearing, put difference in column L. After comparing all the courses we divide the difference of the sums of columns R and L by the number of courses. The quotient is the correction to be applied to each angular bearing.

If the sum of column R is less than L, then each of the angular bearings must be carried to the right by the amount of the quotient; but if the sum of column L is less than R, then each of the angular bearings must be carried to the left by the amount of the quotient. After determining the final courses they can be placed in ink near the original courses for use in plating the work.

EXAMPLE.

	Or. B.	Av. B.	⊳ B.	R	L	True B.
	S 7 W	S 5 W	S 5 W			S 7 W
1 R	3 S 4 W	S 5 W	S 6 W	1		S 8 W
4 L	6 S 2 W	S 5 W	S 2 W		3	S 4 W
2½ L	8 S 5½ W	S 5 W	S ½ E		5½	S 1½ W
2 R	4½ S 6½ W	S 5 W	S 1½ W		3½	S 3½ W
2½ R	3½ S 6 W 4	S 5 W	S 4 W		1	S 6 W

(1— 13) divided by 6 equals 2 R equals correction.

In conclusion I will say that although we have found a method of determining the true angular bearings and of equalizing the courses, yet I do not consider this is any excuse to abate one iota of our vigilance in mine surveying.

We should never set our instrument at the intersection of frogs or near a pile of iron rails, or near any other cause of local attraction, if we can possibly avoid it.

And if at any time we find an unusual difference between the fore- and back-sight, we should investigate the matter, and, if possible, move the instrument back or forward, and get it away from the cause of the deflection.

DISCUSSION.

Mr. Niles.—I think it is impracticable to get a correct bearing at the bottom of the shaft with the needle alone.

Mr. Davison.—The object in surveying coal mines is to find how the lines, rooms, etc., correspond with the land above. If that can be done without the needle it is the best. Usually it takes more time than the proprietor likes to pay for. The shaft is only a few feet wide, and sometimes 500 feet deep. By dropping plumb-bobs at the sides the air will keep them vibrating for a great while. Sometimes steam at the bottom of the shaft makes it difficult to see them.

Mr. Enos.—It is not much trouble to get the lines below but the difficulty is to fix them with the lines at the surface of the ground, and I do not see by this elimination of errors a true way of doing that. We use plumb-bobs.

Mr. Niles.—You use no needles at all?

Mr. Enos.—None at all.

Mr. Hill.—With the plumb-bobs a very small error at the start will be very large at the end.

Mr. Enos.—You have the air shafts to check by in any case.

Mr. D. L. Brancher.—In surveying the coal shaft at Lincoln, we took only those bearings which nearly corresponded, no matter whether they were in distant parts of the shaft or not and discarded those which were widely different, supposing the needle in that case to be influenced by local attraction. We took the mean of all the bearings and came nearly correct.

Mr. Talbot.—As regards compass bearings the methods of Mr. Braucher meets the approval of my mind.

TOPOGRAPHICAL SURVEYING FOR DRAINAGE PURPOSES.

D. J. STANFORD, OF CHATSWORTH.

First, I would impress upon the minds of the drainage commissioners the fact that the object in forming a drainage district should be to furnish an opportunity for the drainage of the wet lands in the entire district; that the drains, to be satisfactory when completed, must have sufficient depth to afford proper outlets for all laterals that may be constructed in the future, whether open drains or tile; and second, that the ditches must have sufficient capacity to remove the storm water from the watershed that is being drained so quickly as not in any way to injure growing vegetation; and third, that these things can not be done certainly and economically without a knowledge of the topography of the section to be drained; and fourth, that this knowledge can only be obtained by a survey. So that ordinarily the first work to be done is a sort of missionary work, or, as it were, the work of educating the drainage commissioners in the work that should be done,—for in many instances the board of commissioners have a better idea of the results they wish to arrive at than of the necessary steps required to reach these results.

How best to do the work in the field will depend somewhat upon circumstances.

If, as is usually the case, there is a ditch or stream that requires to be improved for a general outlet for all the ditches, I would commence my work by a survey of that stream, commencing at the lower end, running tangents from point to point along its course, and measuring offsets, if necessary, so that it could be correctly platted, noting when farm lines were crossed, and measuring to corners when crossing section lines, noting location and course of all branch ditches and other objects in the line that would in any way affect the cost or efficiency of drainage.

Levels should be taken along the entire line, and bench marks established and their location noted at least at every point where a branch ditch enters, and along every section line, or the subdivision line of a section.

In the same careful manner each branch ditch that is well defined, and likely to become a part of the drainage system, should be surveyed.

If the watershed includes lands not included in the district, those lands should be examined, so that the engineer may know with tolerable accuracy their extent and general character.

This work having been done, I would next draw a rough map of the district, on which I would show the farm boundaries, so far as they could be ascertained, with the names of the owners, the approximate location of the farm buildings, and the ditches that had been surveyed, then, taking this map with me, I would go over each forty-acre tract in the district more or less carefully, as the circumstances of the case seemed to require, taking levels at every quarter quarter corner, and oftener if necessary, and in every pond always connecting these levels with some bench before established, so that all elevations shall show from the same datum plain.

I would mark also on the map before prepared the size and location of all cultivated fields, the shape, size and location of all wet lands, and the direction of flow of the sloughs and ditches, the size, location, shape and depth of all ponds. Correct, if necessary, farm lines, location of buildings and owners' names, and also note any peculiarity of soil or topography.

If the district was mostly cut up into farms I do not think it would be necessary to do much chaining while doing this interior work. I would depend much on farm lines for location.

A level with a small compass attached, and stadia, and a self-reading rod, in the hands of a good walker, would be about all the instruments necessary for the work. Having gone over each forty-acre tract in the district in this careful manner, we are now ready to make a topographical map of the district, which may be more or less elaborate, according to the skill or taste of the surveyor, but which should at any rate be neat and plain, and of sufficiently large scale to show all the facts of the survey without confusion. It should show correctly all farm lines, with the location of buildings, and owners' names, all roads and bridges, the location of all ditches in the district and the direction of their flow, besides the location of the ditches surveyed, the cultivated land and the wet land, the courses, shape and size of all sloughs, the location, size and depth of all ponds, and besides this, in some manner, the comparative elevation of all points in the district where levels were taken, except that along the lines of the ditches surveyed, the levels need not be given oftener than once in five hundred feet. Probably as good a way to put in the elevations as any is to write them in with red ink at the point where taken, though contours could be drawn in, in places, to assist the eye in catching elevations quickly.

When the grade is established, I would write the grade below the elevation at least once in two thousand feet along the ditches, and continue to mark down the new ditches in the same way as fast as they were surveyed and the grade established.

With this map the engineer is not only able to lay out the general plan for the drainage of the district, but the commissioners can classify the land for taxation with greater accuracy than is usually done by going over the ground.

The size, depth and proper method of laying out the ditches, and their construction, and the construction of the map and profiles of the various ditches, for the drainage record, very properly come in another paper.

DISCUSSION.

Mr. Bourland.—There is hardly any engineer but what would undertake the work as elaborately planned out, but there are but few commissioners who would go to the expense of providing it.

Mr. Elliott.—I think Mr. Stanford means to discuss what would be the way to do the best and most thorough work, rather than what was done in a particular case.

THE PREVENTION OF ABRASION OF CREEK AND RIVER BANKS.

E. J. CHAMBERLAIN, OF PITTSFIELD.

The wearing away or abrasion may be caused by: First, wave action; second, too great a velocity of the stream; third, an outflow of water through the substrata of quicksand that are generally found under alluvial lands. The water that, during a flood, fills all the beds of sand, running back to the river after the high water, carries with it the quicksand, causing the bank above to cave into the river and be carried away. Frequently the wearing away is done by a combination of all three of the above named causes.

To prevent the injury by wave action nothing is better than a revetment of brush and stone. The mattress upon which the stone is to be thrown should be close enough to prevent the water from carrying away the soluble portions of the bank. Fascines, ten to eighteen inches in diameter, made of willow poles eight or more feet in length, are laid close together upon the bank, if above water, and the same well covered with stone. If the bank to be protected is submerged, the fascines are fastened together by wire or rope, so as to make the desired size, (or section if too large for one mattress), then anchored and sunk to place by throwing stone upon the same.

Those desiring more details will find them, together with illustrations, in the annual report for 1883 of the Mississippi River Commission.

About four years ago I had about two thousand feet in length of revetment made by laying stone close together, by hand, upon a bed of straw about eighteen inches deep. If a muddy stream, the straw will

catch silt, to act as a good substitute. It is upon a levee embankment, with slope of five feet base to one foot vertical, subject to from two to four miles of uninterrupted wind along the Mississippi river, and, though exposed several times to a strong wind at the time when the water reached it, it remains unbroken. For embankment a good sod of Bermuda or blue grass on a flat slope is effective in many cases.

Most of the abrasion of small streams is caused by too great a velocity of its waters. A few small spur dykes are the cheapest and most effective for such cases. They should be well joined, or mortised. so to speak, to the bank, so that water can not wash between the bank and end of the dyke. The end projecting into the stream should point a few degrees up stream, from a right angle to the bank, so as to form a body of comparatively dead water above the dyke. For small streams a few large trees fallen into the stream, with small trees and brush to make all close enough to carry stone to hold it in place, will frequently be all that is necessary for a dyke.

The dykes, as generally made by the United States engineers, are willow mattress alternating with plenty of stone, and, when raised to the desired height, all well covered with stone, care being taken to have an apron extending from the lower side, at the botton, or the water falling over the dyke will undermine the same.

The injury from the third cause is found only along banks of the large streams, or on embankments composed in part of quicksand and subject to one side only being covered with water. For the river bank the revetment above described, or, if room in width of the stream, some dykes so located as to deposit course river sand against the affected bank, will be necessary.

A valuable detailed report of construction, and the result of same, may be found in our exchange from Arkansas, page 51, of 1887, by Captain H. S. Taber.

I will describe a cheaper substitute, used upon a bank of about half a mile of the Mississippi river, that was troubled by all three of above mentioned causes, believing that those who may chance to read this may be similarly situated as to finance,—*i. e.,* not have the United States Treasury to draw from to pay for a desirable dyke or revetment. The river bank was six to ten feet high—and perpendicular—to the surface of low water, and thence about two feet base to one foot vertical for a depth of eight to fifteen feet, with a strong current, but recently directed so as to endanger, striking the upper end obliquely and following the concave bank until deflected towards the opposite shore.

As the river had encroached nearly to the base of the levee, something must be done, or a new levee, costing $8,000 to $10,000, must soon be made, and we had but little money or credit to appropriate for such purposes. Green timber and sand near by could be had for the asking. Large trees, with the tops entire,—all that four mules could draw on frozen ground,—were used. The first tier was placed with tops up stream and the butt kept close against the bank. After I had a good base, then the top end was turned down stream, and large trees,

logs and brush (all green) were rolled off the bank until a wall of five to fifteen feet in width was built higher than the bank. Then large stakes were driven into the bed and vertical bank as would best tie all together. Four dykes, about eighty feet long, and about forty feet wide at base, and fifteen wide at the top, which was above low water, were constructed in a similar manner. The dykes were weighted with a few boxes filled with sand.

The work so constructed remained one year, and was covered with water once. All that had been completed as above remained, and the lower portion was found imbedded in sand and silt. Fearing that it would not be so secure after one summer's seasoning of the timber, I last fall had all renewed by putting a new top on, building it above the river bank about five or six feet, and the dykes about ten feet above low water, and all well covered with stone brought by boat. The stone settled the dykes to near low water, and the balance to bank level. We used but six hundred and sixty yards of stone, which, I think, is not enough. The total cost was about $1,500.

Two men who have much experience on work of a similar nature, and who were valued aids in the construction, predict for it success, as it certainly has been thus far.

MUNICIPAL ENGINEERING—INCLUDING A DESCRIPTION OF THE MUNICIPAL ENGINEERING FEATURES OF SPRINGFIELD.

W. D. CLARK, of Springfield.

The assertion is boldly ventured, that there is no branch of engineering that requires more practical skill and sound judgment than municipal engineering, candidly admitting, however, that other branches require more scientific attainments, but none upon whom rests more weighty responsibilities than that of the municipal engineer, as he is, or should be, the sanitary as well as civil engineer, and who is not only responsible for the best and most effectual drainage and sewerage system, as well as the best methods of grading, draining and improving the streets and alleys, but more especially for the very best and most effectual system of sewerage that can be devised, regardless of the necessary cost, for upon this very principle rests the health and lives of the inhabitants of the municipality. A very grave responsibility is therefore assumed by an engineer when planning a system of sewerage that will not breed the zymotic diseases from which many of our populous cities suffer.

Neither time nor space will allow more than brief suggestions to the municipal engineer,—the study and judgment required in selecting sites for healthful and beautiful cities, as well as the best plan for improving the streets and avenues, the location, dimensions and mode of constructing the sewers, so as to subserve the demands of a populous city.

It would require a ponderous volume to properly elaborate the opportunities, duties and responsibilities of a municipal engineer, and I can only very briefly refer to the various duties and responsibilities devolving upon a successful and practical engineer.

In very few instances, and I might with propriety say never, are engineers called upon, professionally, for services in selecting sites for new cities, which should be, by all means, selected for beauty and healthful surroundings, as well as adaptibility for regular and systematic street lines, gradients, drainage and water supply. When a site is determined upon, the first duty of the engineer is to make an accurate survey of the boundary, and I would most emphatically advocate the importance of a thorough and careful topographical survey of the entire site, and, if admissible, the surroundings for a considerable distance, establishing contours at not more than three feet elevation. Such a survey will be of incalculable value in locating the streets, which, I do not deem essential, should, in all instances be either parallel or straight, but located as best suited to the contour of the site. A public square should be located in the center, of such dimensions as the generosity of the donor may dictate, from which the streets should radiate. It would add much to the beauty of the prospective city if small parks were located in each of the quarters. Extensive park and cemetery grounds should be selected and reserved for elaborate improvements when the population and wealth will warrant. Sites might with propriety be designated for high and primary school buildings. A thoroughfare, sufficiently wide, should be laid out for present and prospective railroads approaching and leaving the site. I do not deem it necessary to elaborate upon the best method of preserving the lines and boundaries, more than to emphasize the necessity of having every line of the survey measured with the utmost care and accuracy, regardless of what the value of the land may be. Carefully marked stone monuments should be set at the angles and intersections of the streets, placed sufficiently below grade as not to be disturbed when the streets are improved. A system of grades should be carefully studied and established throughout the entire system of streets, and the engineer will be surprisingly and successfully aided in this part of the work by the topographical map. When grading the streets and alleys, permanent and elaborate improvements should ever be kept in view. Streets should be wide,—not less than eighty feet,—and surrounding the central square one hundred feet would be admissible, so as to allow for wide sidewalks fronting business blocks. In the residence portion no fences should be permitted, the street improvement designed for a lawn of about four feet between the property line and sidewalk, with

shade trees planted in the center, a sidewalk sufficiently wide to meet the convenience of pedestrians, and a lawn between this and the curbing, with another row of trees. Thirty feet is sufficient width for the paved portion of the streets in the residence part of the city.

The next matter that should engage the attention of the engineer is an elaborate and carefully studied system of sewerage and drainage, leaving out, as I do, the matter of water supply, which, to discuss, will demand more space than intended in this paper. A system of sewerage should be projected that will meet the wants of a populous city; and here the topographical map will aid in determining upon the route and dimensions for each branch of the system. Engineers differ as to the best system for successful sewerage, some advocating the so-called "separate" system, while others, with equal persistence, advocate the "combined," or "single," system. For myself, my prejudices are in favor of the "combined" plan. The storm-water will be of utility in flushing and cleansing the sewers. Their dimensions should be sufficient to successfully drain the territory embraced in the district the topographical map will indicate. Provision should be made for ventilating and flushing each branch of the system by standpipes, placed at proper localities, or pipes leading into the smoke-flues of tall chimneys, and placing flush-tanks at all dead ends. Man-holes should be located at the intersections of the streets and at the junctions of lateral sewers. I deem it a wise suggestion to run lateral sewers in the alleys, as in almost every instance they are more convenient of access than where placed in the streets.

The engineer must inform himself as to the best material and mode of construction. For sewers of two feet or more in diameter, I believe good hard brick, moulded to conform to the radius of the sewer, the invert carefully and solidly bedded in cement, the intrados plastered with a thin coat of Portland cement, so as to make them absolutely impervious, will fulfill all the conditions for a good sewer. The crown might be laid dry, so as to permit the surplus water in the soil to percolate into the sewer.

Careless construction has been the fruitful source of most, if not nearly all, of the zymotic diseases from which our cities suffer, and it devolves upon the engineer to see to it that health and lives are not jeopardized by carelessness and indifference in construction. In the city of Springfield, up to within the last three years, the bottom courses of the invert have been laid dry, allowing the poisonous liquids to percolate through and contaminate the soil, and scarlet fever has usually originated in that part of the city where the conditions, from careless construction and irregular gradients, breed the disease. Sewers of three feet and over in diameter were constructed with a double ring. A single ring, if good bricks are used,—none other should be permitted,—is ample for a diameter up to five or six feet, and in solid sub-soil and in deep excavations a very much larger diameter might, with perfect safety, be constructed with a single ring, saving thereby from thirty to forty per cent. in cost. I can not leave this branch of my subject without em-

phasizing the importance of thorough and exceedingly careful study to secure the very best system, and construction for effectual and successful drainage.

Sanitary engineers have made the mistake by constructing sewers of too small calibre, and not placing them sufficiently deep,—nine feet,—and in no case should the minimum be less than eight feet, the maximum will be controlled by the contour of the territory drained.

Coming down to street improvements the engineer will be confronted with such a variety of pavements, and embarrassed with such a variety of opinions from municipal authorities, to say nothing of the voluntary advice and suggestions that he will be compelled to listen to, that he will be at a loss to determine what is best. I am sanguine that brick is the best in cities where the traffic is light, and hazard the opinion that not in the distant future brick will be the material used on streets subject to the heaviest traffic, and in this, as in sewer construction, economy and durability should be the zealous study of the engineer. My ideal for a durable and economical pavement is to grade the street to the proper contour, place tiling about three feet below the grades in the gutters, connecting them with the street inlets; roll the surface thoroughly with a ten-ton steam-roller,—fifteen tons would be better,—place a course of hard-burned brick flatwise upon a thin bed of sand, gaged to an even surface; fill the interstices with dry sand; upon this spread an inch of sand, and select hard, tough brick of common size, set on edge; pass over a light roller, and fill the interstices with Portland cement, or, what I deem best, asphalt. Such a pavement is not expensive, and I do not hesitate to stake my reputation upon the assertion that it is, all things considered, the best.

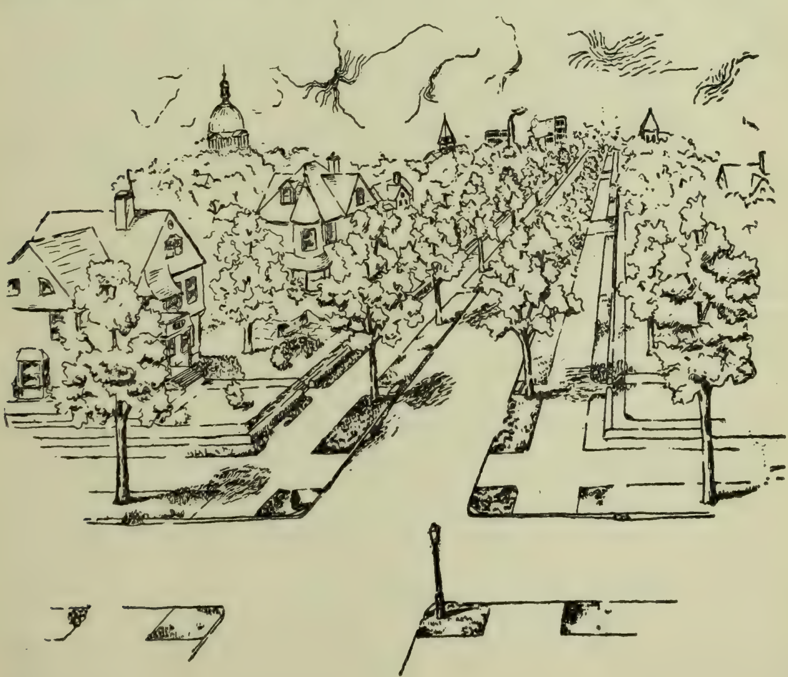
When the engineer has accomplished his preliminary work, to carry out and complete his designs will require constant care and untiring watchfulness. Detailed plans must be prepared for the several parts of the work projected, which must be drawn with care and accuracy, specifications prepared and carefully guarded, contracts, written and executed. It is a custom to have contracts drawn by the city attorney. A competent engineer knows best just what is necessary to be embodied in documents prepared for the construction of public works. Constant watchfulness will be required on the part of the engineer if he is desirous of securing careful and honest execution of his designs. A young engineer should make it a point to carefully watch and profit from the success of those older and more experienced in the profession, and aim, also, to profit by their mistakes.

Elaborate and very instructive essays might be written upon each branch of my paper, my motive being more to hint to what, rather than how to perform, the functions of a municipal engineer.

It is a common error, especially among young engineers, to be led astray by the eccentricities of self-conceited persons, having more cheek than brains, and whose sole aim is to see their names in print and gain a little notoriety,—not that I am in the least disposed to disparage the honest and zealous efforts of ambitious engineers, but am always heartily

glad to award all merited praise for every honorable effort,—but, a young engineer especially, should be very careful, as well in his profession as in his religion, to resist the temptation of being carried away by every "wind of doctrine." My advice, therefore, is, Never adopt any advanced idea, however plausible it may appear, without cautiously and very carefully weighing every proposition before giving unhesitating indorsement. At the same time he should never fail to investigate and encourage every proposition in the interest and advancement of the profession.

Of all the professions, that of civil engineer and surveyor is the poorest paid and least appreciated, unless it be the municipal engineer, whose qualifications consist in being an energetic and aggressive politician. If a physician fails to properly diagnose the disease of his patient, and the patient dies, it is attributed to a wise dispensation of Divine Providence. If a lawyer, through failure to successfully advocate or combat a technicality, loses a suit, his client quietly submits; but if an engineer fails, through causes over which he may have no control, dictated, as he often is, by a higher official power, he is held responsible for whatever jeopardizes health and lives. I hope the time is not in the distant future when practical ability, talent and honest zeal, will be appreciated as merit deserves.



Springfield, the capital city, and county seat of Sangamon county, is about twenty miles west and three miles south from the geographical center of the State, in latitude 39 deg. 48 min., and longitude 89 deg. 39 min., is six hundred feet above sea level, and two miles square. The villages of North Springfield and Ridgely border on the north, and West Springfield and South Springfield on the west and south. Springfield city contains about 30,000 inhabitants, and there are about 7000 in the villages. The southwest and east is prairie; the northwest is timber land. A small stream runs from the southeast quarter in a northwesterly direction through the city, in which the main or "Town Branch" sewer is located, and a small branch runs from the northeast quarter westwardly into the "Town Branch," in which the "Kelley Branch" sewer is located, thereby giving sufficient outlet for sewerage and drainage, which, in connection with the "Cook street and Bergen Branch" and "Allen street and Williams Branch," effectually meets the demands of the population.

Springfield adopted the "combined" system of construction. The first sewer built by ordinance was in 1857. Thirty-two miles have been constructed. Brick has been the material used in the entire system, with the exception of about eight hundred feet of fifteen and twelve inch crock pipe. I feel warranted in the assertion that Springfield can boast of a system equal in efficiency to any city of its size in the State. Several lateral sewers in addition to those already constructed are contemplated for the coming season, and additions will be made, from time to time, as they may be required.

The city has twenty and three-fourths miles of streets and alleys paved, of which only about one-half mile is of brick; the balance, with the exception of about one-fourth of a mile, which is macadam, is red and white cedar.

While the improvements have not been just what I would have dictated, I am warranted in the assertion, that for salubrity of climate, beauty of location, attractive buildings and beautiful lawns, it will compare with the finest cities of the State, dubbed, as it very appropriately is, the "Flower City."

A vein of very superior coal underlies the city and surrounding country. The topography is such that no very great amount of engineering skill is required in improving the streets and sewer construction, more than devising the best plans and methods of construction.

I assume it will be a matter of interest to many to be informed upon what principle our public improvements are constructed. The City Council first passed an ordinance, giving in detail the character of the improvement, its location, and the manner of providing for the payment of the same, whether from the general fund set apart for the purpose, or by "special assessment for local improvements." The method adopted by Springfield since 1882, with the exception of main sewers, which have been paid out of the general fund, is to assess the cost of construction, cost of assessing, collecting, court fees and superintending, against the abutting property,

assessing the city for the portion in the street intersections, and, within the last three years, including street inlets and man-holes. The same course has been pursued in assessing and collecting for street improvements.

In opening and widening streets, the practice has been to assess by special tax all the lots, blocks and parcels of land that may be benefited, in proportion as they are actually benefited.

The Mayor, Comptroller, City Engineer and City Superintendent of Streets, together with such other officers as may be prescribed by ordinance, are known as the "Department of Public Works."

Springfield has now an inspector of sewers, whose duty is to inspect all sewers in process of construction and attend to the repairing and tapping for house-drains, etc.

The commissioner of streets has charge of the repair and cleaning of the streets, avenues and alleys, and the supervision of the construction of all sidewalks which are provided for by ordinance, giving a description of the lot, block or parcel of land, the name of the owner and the character of the walk to be laid. The course pursued in Springfield is to include in an ordinance all the lots, blocks and parcels of land in the city where sidewalks are needed, giving a full description of the same, and name of owners, and let a contract with some responsible person for their construction, as may be ordered by the Mayor, upon the request of the committee on streets and alleys, the cost of which is assessed against the abutting property. A discount of ten per cent. is allowed upon all special assessment collections when payments are made within ten days from completion and acceptance of the work.

DISCUSSION.

Mr. Burnham.—In reference to the question as to engineers not being selected to lay out original town sites, I will say that one of the men who laid out the city of Danville, in this State, was a practical surveyor. He saw that the tract of land was an excellent one for the location of a city, and urged others to join him in laying it out and settling it. His name was Dan Beckwith, and the town was named after him, for his simple christian name of Dan.

Mr. Baker.—The city of Washington was laid out and planned by engineers at its beginning. The village of Pullman also was planned in the same way. I could probably cite many more cities which have been planned satisfactorily, but the city failed to materialize.

CONSIDERATION OF A LAW COMPELLING THE RECORDING OF PRIVATE SURVEYS.

Z. A. ENOS, of Springfield.

Many attempts at legislation have been made, and much has been written and spoken, in favor of a law compelling the recording of all private surveys, and the making of the county surveyors the recorders of these surveys, and their records the official records for that purpose. In this paper I will attempt to state briefly some views regarding such a law that forcibly strike my mind, and, First,

WITH REGARD TO THE COMPULSORY RECORDING:

If all surveyors were receiving from the public treasury adequate compensation in the way of salaries or fees, then there would be perfect equity in the demand, and an unquestionable right in the public to require the surveyors to make full, true and perfect records of their acts and doings in regard to such surveys, for the surveyors would all be, in effect, public officers, of whose official acts and duties the public would have the undoubted right to be informed, and the power to control, and records made in obedience to such legal requirements would be public records. But it appears to me there is a very marked distinction between the rights and powers the public can justly claim and exercise over its officers, their acts and duties, and that which it has a right to demand aud enforce from and over *private* individuals and their transactions.

These surveys so made by private individuals, employed by private citizens, and which affect only private rights, are the private affairs of the employer and the employed, and the facts and information therewith connected and thus acquired (and which are sought to be obtained by the compulsory recording) are the private property of the surveyor and his employer;—as much so as the results of intellectual or manual labor and skill in any other profession, trade or occupation, are private property. Such an enactment, without providing for a reasonable compensation to the surveyor, would look very much like conflicting with that Constitutional provision that prohibits the taking of private property for public use without just compensation; and if intended for the particular benefit of a certain class of surveyors, (as the arguments advanced in its support would indicate) then the law would be subject to the additional objection of being special, or class, legislation. Nor can such a law be

justified on any of the grounds that authorize the legislative control over private individuals and private affairs. It can not be justified as tax for revenue purposes, for it does not provide for putting anything in the public treasury; and it certainly can not be claimed as authorized under the police powers, (that judicial drag-net) for it is not necessary for the peace, health or comfort of the community, or any purpose of police control; and I am totally unable to perceive any legislative authority for exercising such arbitrary power over private citizens and their private transactions. This is all I shall say on the legal view of the question.

Next, as to

ITS EXPEDIENCY AND EQUITY.

I would consider such a law, requiring the surveyor to record all the evidences and steps taken by him to ascertain the correct corners and boundaries of a tract of land in each private survey, as unjust and unreasonable,—as unreasonable as it would be to demand of the lawyer to record the authorities and reasons for each opinion he may give a client, or of a doctor that he shall record the nature and character of his patient's diseases, and his course of treatment for the same, or the architect the plans, details and estimates for every dwelling-house. The accuracy of the corners and boundaries of the land surveyed, in the first case, the soundness of the legal advice, in the second, the successful treatment of the disease, in the third, and the style and cost of building, in the last, are what the land owner, the client, the patient or builder are interested in and desirous about; and the evidence and course of reasoning by which they arrived at their facts or conclusions are matters that belong exclusively to the employer and employed, that neither the public nor any individual has a right to demand that they shall be recorded for their benefit, and much less at the former's expense. On what foundation in reason is it that the professional knowledge, skill and acts of the surveyor are more public property, to be appropriated and used for public benefit, than are the knowledge, skill and ability of the lawyer, doctor, architect, or the various trades, professions or occupations? Why should the surveyor, when he has, by hard labor, diligent investigation, or thoughtful study, acquired important information in his profession, be required to proclaim it to all the world by making a public record of the same? Why should he be made the exception to all other professions or occupations? Or why should the party employing him be compelled, after having paid for establishing his neighbor's corners, to furnish that neighbor (by record) with all the evidences of the manner in which it was done,—and that gratuitously? An attempted justification is sought to be made for this distinction on the ground that surveys are matters of general interest, that affect the public, and the others are purely private transactions. Wherein is there such a real difference? For instance: A gets a surveyor to establish a corner of his land, and employs a lawyer to give an opinion on the legality of the corner thus established; are they not both strictly private transactions? Or if the survey, as is claimed, is by nature of its subject,—viz., land,—a matter

of public interest and importance, and therefore should be recorded for the benefit of the public, should not the legal opinion of the lawyer, sustaining the legality of the survey, for the same reason be placed on record? This appears to be a logical conclusion from the premises. But this conclusion, if presented as an independent proposition, would be unhesitatingly rejected by the legal fraternity, while at the same time they, as legislators, are the most strenuous in insisting on loading upon our shoulders a burden such as they would be unwilling to carry. In the position here taken, I do not wish to be understood as regarding all surveying as mere private transactions, or as contending against all recording of surveys, for there is a large class of surveys that are strictly public, such as railroads, canals, highways, towns, cemeteries, and the like surveys, that interest and affect many persons and communities. These are properly required by law to be recorded in the Recorder's office, and for which the surveyor makes a plat and certificate, (and gets pay therefor) and that the Recorder copies in his official record, and for which service the Recorder is paid. But I allude to that other and larger number of ordinary land surveys, usually designated as "private surveys," wherein individual interests are represented, in contradistinction to aggregate or community interests, such as the survey of a farm or town lot, and in such cases I can see no good reason why the surveyor should be required to publish all he has done and knows about the survey, or the employer compelled to pay for the publication. It is their own time, labor and money that has been expended upon the survey, neither the owners of the adjoining lands nor the public contributing anything, and whether they are willing or able to expend any more, they alone should be left to determine. It is not a case wherein the State is justified in interfering, and, in effect, saying, "inasmuch as you have, at your own expense, established the corners and boundaries of the land, you must now pay for having the survey recorded, so that the neighbors may know all about it and be equally benefited with yourselves." It is the clown's logic, that "one good turn deserves another,"—that is, you did a good act in surveying the land, and for that reason you must do another in having it recorded. It makes no difference that the surveyor keeps the notes and plat of the survey, and has given the employer a certified copy; others have not the same benefit of his knowledge and the employer's expenditure that they have, and therefore they must pay more that the others may enjoy these benefits equally with themselves. True, after what has been done, others may, at much less expense than they have been at, obtain the same information, yet, as the others do not choose to do it, therefore the surveyor and employer must supply it,—in effect, attaching a penalty to a commendable act. It would hold out little inducement to the liberal and enterprising men to establish and perpetuate the evidences of land boundary, when they know that others are to reap gratuitously what they sow. And it would encourage the covetous or careless to refrain from making or aiding in any surveys themselves, because they would have the full assurance that whatever

others might do, they would enjoy it equally, without cost to themselves of money, labor or time in the obtaining of the same.

I do not wish to be considered as running amuck against the recording of all private surveys, but only as warring against the compulsory obligation to record. I would place the recording of such private surveys, unless paid for by the public, entirely at the election of the parties. If they desired to make a public record of the survey in order the better to perpetuate the evidence of it, and were willing to pay for the recording in the Recorder's office, (the only proper place for the recording of all matters relating to land) they should have the right to the recording of the surveyor's certified plat and field notes; that when so recorded it shall be notice (as in like case of deeds) to all the world of their claim of boundary, and that such recorded certificate, record or certified copy of such record, should be *prima facia* evidence. And the only penalty that I would attach for the failure to record would be, that it should lose its *prima facia* character as evidence, as against any and all subsequent record surveys. So far, and no farther, would I be willing to go.

If, for the reason claimed, or any other cause, a record of such private surveys should be required to be made for the use of the public, there can be but little question by whom it should be made and where it should be kept. Such surveys being frequently essential parts of the calls of deeds, or else notice of the boundaries claimed under the deeds, public convenience would therefore demand that the same should be kept in the Recorder's office with the record of the public surveys and the evidences of title, so that the surveys and deeds could be readily consulted and compared. And as the copying of the plats and field notes of the surveys is but clerical work, not even demanding the skill of a professional draftsman, much less the service of a regular surveyor, there is therefore no necessity or excuse for making the recording of the private surveys an exception from the duties of the Recorder, who has performed the recording of the public surveys for more than sixty years.

DISCUSSION.

Mr. Niles.—I do not know of a demand for the recording of surveys as mentioned in the paper. People have been educated somewhat by county surveyors. I have always surveyed for more than one man. One paid and one did not. There were always two interested parties. Except by surveyors themselves, surveys are not much sought for.

Mr. Enos.—At every meeting of the Legislature for the last twenty years efforts have been made to enact such a law.

Mr. Talbot.—The city engineer of Aurora has written me, that so difficult is it there to re-survey old additions from the records, that he is urging the passage of a city ordinance requiring the approval of the city engineer to a plat before adoption and recording.

Mr. D. L. Brancher.—That reference recalls the plat of an addition in the city of Lincoln, in which the surveyor, in his description, mentions streets, alleys, their widths, etc., and states: "All other lots, blocks, etc., of the plat, are as marked thereon,"—when, in fact, no dimensions are marked thereon.

Mr. Enos.—The ordinance which the Aurora engineer is seeking to pass is against the State law, and would be void if passed by his city.

Mr. Balcom.—He might be able to carry it out in Aurora, though not elsewhere. In making re-surveys of lots in Champaign I have found many buildings and fences wrong. In one instance a three-story business house was two feet in the street. The errors come mostly from ignorance. I have asked the city to furnish corner stones, and they have done so willingly. I think the county ought to furnish every surveyor with stones for all old government corners.

A DESCRIPTION OF THE NEW WATER WORKS PLANT FOR PEORIA, ILLINOIS.

W. C. HAWLEY, OF PEORIA.

When this article was promised, it was expected by the writer that the plans for the new water-works for Peoria would have been sufficiently near completion by the present time to permit of a full description. It is to be regretted, however, that while part of the plans are completed, together with the specifications, and some contracts have already been let, there still remains much to be done. For this reason it will be impossible to enter into a description of the pumping station and its machinery, and the details of the water supply, as the plans for them are still in the rough, and liable to material change before they will be definitely decided upon.

Peoria's present water-works system was built in 1867-68 by the city, the Holly Manufacturing Company, of Lockport, N. Y., being the contractor for the work. The supply is by direct pumping, and is taken from a filter gallery on the west bank of the Illinois river, about a mile and a half above the central part of the city. At first two rotary Holly pumps were used, but these have since been removed. and there are now a Deam, a Cameron, and one compound duplex, and one high-pressure duplex, Worthington pumps, with a capacity of three and a half million gallons per twenty-four hours. At present the Cameron is supplying the

bluff, and the others are used for the low service. There are about forty-four miles of mains, from sixteen to four inches diameter, three hundred and seventy hydrants, and three thousand taps.

There has been very little done as yet by the new company in the way of extensions or improvements to the old system, owing to the short space of time which has elapsed since it took possession of the works, and the magnitude of the work of preparing the plans for the changes which are to be made. Consequently the works are in only a slightly better condition than they were when owned by the city. Work on the extensions, etc. is to begin early in the coming spring.

As to the condition of the works at present: The pumps are working at near the limits of their capacities. They are in fairly good condition, though the high speeds at which they sometimes have to be worked cause considerable pounding. They are all low-duty pumps, so that the plant is not an economical one. The boilers are of the large flue type, with mud drums, and while the exhaust steam from the Cameron pump is used for heating the feed water, there is no device used for purifying it.

The mains are, so far as known, in good condition, but there are very few circuit valves in the system. A very commendable practice has been followed, however, in placing valves on nearly all the hydrant branches, so that the hydrant can be shut out, and repaired without shutting off the water from any of the mains. The following hydrants are in use: Holly, Galvin, Ludlow, Matthews, Bourbon and Chapman. The present works are barely able to supply the amount of water needed now, and were it of such quality that it could be used generally for domestic purposes, they would be totally inadequate.

The city of Peoria is bonded to very nearly the statute limit, and therefore could not rebuild or extend the works, hence, within the past year, having framed a suitable ordinance, the common council received bids, and. after a long consideration of the matter, the works were sold to the firm of Moffett, Hodgkins & Clark, of Syracuse, N. Y. It is unnecessary to enter into the financial part of the transaction, but is sufficient to state that part of the agreement was, that this firm should make additions, extensions and improvements, in conformity with the ordinance then passed, and should maintain and operate the works for a period of thirty years, the city having the right to buy the works at the expiration of certain stated intervals. In the meantime Moffett, Hodgkins & Clark transferred their interests to the Peoria Water Company, of which J. F. Moffett is president, Chester B. Davis, vice-president and engineer, J. L. Hotchkin, treasurer, and W. H. Fritchman, secretary and superintendent, and which company is now operating the works, having taken possession of them November 2, 1889.

As to the new system: The ordinance called for a new supply of water other than the river, and acceptable to the council,—for a total of seventy-five miles of mains in the city limits, from thirty inches to

four inches in diameter, of which not more than twenty-three miles shall be six-inch pipe, and not more than seventeen miles shall be four-inch pipe. On these seventy-five miles of pipe are to be located one thousand hydrants, of which ten are to be six-nozzle hydrants, and one hundred to be four-nozzle hydrants. Each hydrant supplied from an eight-inch pipe or larger must have a valve between it and the main. There are to be two storage reservoirs, the flow lines of which are to be at an elevation of three hundred and twenty feet above city datum,—that is, two hundred and twenty feet above the corner stone of the Peoria County Court House,—and two stand pipes, one on the East Bluff and one on the West Bluff, the combined capacity of the reservoirs and stand pipes to be at least sixteen million gallons.

The preliminary survey and examinations for this work were carried on under the direction of Mr. Chester B. Davis, member of the American Society of Civil Engineers, of Chicago, who is the engineer for the Peoria Water Company, and the plans are being prepared in his office.

The first thing to be considered was, of course, the source of supply. It was found, after making an extended series of borings, that there exists a sub-stratum, of a coarse gravel and sand, along the west bank of the Illinois river, extending from the Free Bridge road northerly for a distance of four or five miles. Borings made from one to two miles west of the river, in the valleys running back into the bluff, show that this stratum extends back under the bluff, and borings in the river bed show it to extend underneath the river, though, as has been amply proven, having no connection with it.

This bed of gravel and sand varies from ten to twenty feet in thickness, and water is encountered as soon as the drill enters it. Laying above it are various thicknesses of very heavy and compact yellow or brown clay. On the flat, between the bluff and the river, and extending under the river, the clay is from ten to twenty feet in thickness. From the character of the gravel struck in the borings it was decided to put down an eight-feet test well at a point about seven hundred feet from the river, just north of the Free Bridge road. After going through nineteen feet of heavy brown clay the gravel and water were struck. From this point an eight-inch brick wall was sunk on a wooden shoe, a centrifugal pump with an eight-inch discharge being used to pump out the water. A weir box was made and a record kept as the work progressed. At a depth of twenty-eight feet, or when in nine feet of water, the well was supplying over one and a half million gallons per twenty-four hours. Within an hour after this measurement was taken, and while the pump was running as usual, the water in the well suddenly raised about two feet, and the pump was unable to lower it sufficiently for the laborers to continue digging, consequently further work in it was abandoned. After this sudden increase in the flow the well yielded one million, seven hundred and ten thousand gallons per twenty-four hours. Steadily pumping for several days failed to lower it more than one or two inches.

Now to show that the water in this sub-stratum of gravel has no connection with the river: In the first place, the chemical analysis of the well and river waters show them to be totally different in character. It is unnecessary to enter into the details of the analysis. The river water is very impure, containing much suspended matter, showing unmistakable signs of organic contamination, and containing some sulphate of calcium. The well water, on the other hand, is perfectly clear and pure, and contains no sulphate of calcium, the only sulphates present in it being very small quantities of sulphates of sodium and potassium. But the strongest proof that the river has no connection with this sub-stratum is this: Before the well was dug, a six-inch pipe was driven in the river bottom from the draw rest of the Free Bridge. Fifteen feet of clay were passed through before the gravel was reached. Water rose in the pipe till the surface was about six inches above the river level. The pipe was driven about forty feet and left. The river afterwards fell four feet, but the water in the pipe only fell about two inches. When the well was dug, the surface of the water in it was found to be at exactly the same elevation as that in the pipe, though they were over one thousand feet apart. It was afterwards found that whenever the pump in the well was run continuously for twenty-four hours, the water level in the pipe was lowered about one to two inches, and that further continued pumping failed to lower it more. It, however, resumed its original level within a short time after the pump was stopped. The water in the pipe and the well remained, in November, when last examined, within an inch or two of its original level, and it stood for several weeks last summer four feet higher than the water in the river during the period of low water.

Three well-known chemists have analyzed this water, and agree in pronouncing it pure, and good for all purposes, including its use for boilers. It was used for about six weeks in the boilers which furnished steam for running the pump at the well, and when cleansed the boiler was found free from scale, and only a small quantity of grey mud, or "sludge," was taken from it.

This water will probably be collected in one or two large wells, or an underground gallery. There are to be three six-million high-duty pumps, and a duty of at least one hundred million will be required. There will be a plant of boilers sufficient to furnish one thousand horse power. There will be an automatic stoking device, and also one for removing the ashes. The exact location of the pumping station has not yet been determined, but it will be very near the test well which has been mentioned. The elevations of the pumps will be about thirty feet above city datum, so that there will be a head of two hundred and ninety feet to pump against when the reservoirs are full.

As I said in the beginning of this article, I am unable, because of the incomplete condition of the plans, to enter into further details of the pumping plant. The force main is thirty inches in diameter. It will follow the Galena road into the city limits. About a quarter of a mile

from the pumping station the thirty-inch line to the reservoir branches off, so that when pumping, the surplus above what is being used in the city will go to the reservoirs for storage. The distance from the pumping station to the reservoirs will be about seven thousand feet.

The land purchased by the company for the reservoir locations is the south-east quarter of the north-east quarter of section 27, town of Richwoods, and is about four miles north-west of the Peoria County Court House. On this land are the sites for three reservoirs. Two are to be built at once, and the other site will be utilized when further storage capacity becomes necessary. The reservoirs to be built in the spring will each contain about eight million gallons. A deep ravine heads on this land in two short, deep forks. Their sides and bottoms are of very heavy brown clay. An earth embankment will be built in each fork, just above the junction of the two, the material being taken from the sides of the ravines above the embankments. A heavy puddle-wall will be built in each embankment. A valve well will be constructed in each embankment, through which will pass the supply-pipe and an eight-inch mud pipe. The embankments will be twelve feet wide on top, with slopes of two to one on the outside, and one and three-quarters to one on the inside, to below the flood line, thence two and one-half to one to the bottom of the embankment. The elevation of the flow line will be three hundred and twenty feet above city datum, and the top of the embankments will be four feet higher. The inside slopes will be paved with brick and stone, and the bottom will be lined with gravel rammed into the clay.

The pipe system within the city limits will be a very strong and efficient one. The thirty-inch supply main extends from the Galena road, on Adams street, to Main. From Main street to Western avenue,—the south city limits,—will be twenty-inch pipe. A line of sixteen-inch will run from the thirty-inch on the Galena road, along north Jefferson, Abington, Madison, Cornhill, Perry, Spring and Bluff streets, to the East Bluff, to the stand pipe at Illinois and Peoria avenues, thence, across on Knoxville avenue, Crescent and Main streets, to the other stand pipe on the West Bluff, at Bourland and College streets, thence, on Saratoga, Second and Webster streets, Lincoln avenue and Helen and Cass streets, to the twenty-inch main. This sixteen-inch line on the Bluff, and the thirty-inch and twenty-inch line main on Adams street, are connected by several twelve-inch and ten-inch mains, and the districts thus formed are further subdivided by eight, six and four-inch mains, until the entire city is covered with a net-work of pipes. One thousand is a larger number of hydrants than is usual, and they will be placed very thickly in the business portion of the city. This is a good practice, however, as "hydrants are cheaper than hose." About one thousand valves will be required, from thirty-inch to four-inch, in addition to those now in.

The pipe weights will be as follows:

30-inch Heavy, (used below the bluff)	350	lbs.	per	foot.
30-inch Light, (used on the bluff)	285	"	"	"
20-inch	190	"	"	"
16-inch Heavy	130	"	"	"
16-inch Light	115	"	"	"
12-inch Light	84	"	"	"
10-inch Heavy	65	"	"	"
10-inch Light	58	"	"	"
8-inch Heavy	48	"	"	"
8-inch Light	42	"	"	"
6-inch Heavy	33	"	"	"
6-inch Light	31	"	"	"
4-inch Light	19	"	"	"

There are eleven miles of the present mains to be taken up, and a total of about forty-five miles of pipe to be newly laid.

The stand pipes are to be built of steel, triple and double-riveted on vertical joints, single-riveted on horizontal joints. The foundations are to be of concrete. A small chamber near the circumference of the stand pipe will be arched over, and from this the sixteen-inch water pipe will pass through the bottom of the stand pipe vertically.

The depth of the foundations will depend somewhat on the nature of the soil encountered, but will be in the neighborhood of eight or ten feet. The diameter of the foundation at the bottom will be forty feet, and the pressure per square foot of area will not exceed two tons when the stand pipe is filled.

The stand pipe at Illinois and Peoria avenues is to be thirty feet in diameter and eighty-five feet high. The bottom course of plates will be three-quarters of an inch thick, of sixty-six thousand steel, riveted with one-inch steel rivets. The top course of plates will be a quarter of an inch thick. The bottom and the first ring will be riveted inside and out to six-inch by six-inch angle irons.

The stand pipe at Bourland and College streets will be twenty-five feet in diameter, and one hundred and twenty feet high, and will be constructed similarly to the other. The bottom course of sheets will be three-quarters of an inch thick, and the top sheets a quarter of an inch thick. Each stand pipe will have a handsome cresting and balcony at the top, supported by brackets, and giving a space two feet wide on which to walk around the stand pipe at the top. Both stand pipes will be open at the top.

The cost of the plant will be in excess of $1,500,000. It is expected that it will be in operation by the latter part of next fall. It is not decided what valves and hydrants will be used. Ludlow's have been used in what work has already been done by the company.

That Peoria has not suffered severely from losses by fire is due wholly to good luck, for with a fire once beyond control in the business district the old system would have been of small service in checking it,

and if a main should burst at such a time, the chances are that it would be impossible to close it out of the system with the present small number of circuit valves. With the new works the pressure will be sufficient to render the use of steam fire-engines unnecessary, and thus reduce the expense of maintenance of the fire department. The pure water will indeed be a boon to the people of this city, who heretofore have had to depend on cisterns, or the delivery of spring water in jugs. The increased number of hydrants should reduce insurance rates, and this, with the reduction in water rates, should give the people of Peoria all the advantages of the new system at a less cost than that of the old.

The plans are being worked out with the utmost care, and with the intention on the part of the company and its engineer to have these works, which will be the largest in the State, outside of Chicago, thoroughly modern—a model of completeness, and as nearly perfect as possible.

DISCUSSION.

Mr. Baker.—Does the contract with the city allow water to be used for street sprinkling?

Mr. Wightman.—Yes, when arranged for with the city authorities.

NOTES ON THE USE OF CEMENT MORTAR.

IRA O. BAKER, OF CHAMPAIGN.

That we may certainly understand each other, permit me a few elementary definitions:

Common lime is made by heating nearly pure carbonate of lime,—limestone or marble,—sufficiently to drive off the carbonic acid. Common lime mortar hardens by absorbing from the atmosphere the carbonic acid which was driven off in making the lime. It will never harden under water, or when excluded from the air.

Hydraulic lime is made by exposing limestone containing from ten to twenty per cent. of clay to a comparatively long-continued and high heat, which drives off the carbonic acid, and causes a chemical combination to take place between the remaining elements. The common lime in the compound causes the whole mass to slake, while the compounds of clay with the lime cause it to act, to a moderate extent, under water.

Hydraulic cement is made by submitting a limestone containing about twenty per cent. of clay to a long-continued and very high heat, which drives off the carbonic, and causes all, or nearly all, of the clay to unite chemically with the lime. As there is little or no free lime in the residue, it will not slake on the addition of water, and hence must be reduced to powder by grinding between ordinary millstones.

There are two classes of hydraulic cement,—Portland and Rosendale. The latter is frequently called "natural," "American," "domestic," and "Roman,"—all of which are misappropriate. Portland cement is heavy, slow-setting, and has great ultimate strength. Rosendale is less heavy, sets more quickly, and has less ultimate strength than Portland. Roughly speaking, Rosendale weighs about two-thirds as much as Portland, sets in one-tenth of the time, and attains to about half the ultimate strength. There is a great variety of brands of each class, which differ from each other in minor particulars.

Nearly all masonry is laid in lime mortar, in which case the mortar is the weakest link, both in strength and in durability. This is particularly true of buildings. When a brick building burns, it is noticed that the masonry tumbles down as rapidly as the wood burns up. If well built with good mortar the walls would stand intact even though the interior and roof did burn. Again, nearly all brick buildings, after having stood ten or fifteen years, require a considerable amount of pointing up, particularly in damp places and against chimneys. The strength and durability of the masonry could be greatly increased by replacing even part of the lime with cement. The mortar for the "ordinary brick work" of the United States public buildings is composed of "one-fourth cement, one-half sand, and one-fourth lime." Many private builders reinforce lime mortar by the addition of hydraulic cement, and many railroads employ cement mortar in all masonry structures, and cement mortar is generally used for sewers, arches, and important masonry constructions; but it is nevertheless true that altogether too much lime mortar is used. Under most favorable circumstances as to exposure to the atmosphere, lime mortar will attain a maximum strength of about fifty pounds per square inch, as compared with a possible three hundred for Rosendale and five hundred for Portland.

The addition of cement to lime mortar adds to its strength,—the strength of the resulting mortar being intermediate to the strength of the two separately. However, it is not certain that it is true economy to mix lime and cement. As far as strength is concerned, the lime, under favorable circumstances, is but little better than an equal volume of sand, and, under water, in damp places, or in thick walls, it is not as good. Lime mortar taken from the walls of ancient buildings has been found to be only fifty to sixty per cent. saturated with carbonic acid after nearly two thousand years of exposure. Lime mortar two thousand years old has been found in subterranean vaults in exactly the condition, except for a thin crust on top, of freshly-mixed mortar.

The strength and durability are unquestionably mainly dependent upon the mortar, and it is highly illogical to insist upon a high quality of stone or brick, or of stone instead of brick, and then use common lime mortar. Experiments show that an increase of fifty per cent. in the strength of the brick shows no appreciable effect on the strength of the masonry, and that the substitution of a Portland mortar for a lime mortar adds seventy per cent. to the strength of the masonry; and also that the substitution of a Rosendale mortar for one of lime adds fifty to sixty

per cent. Probably the difference in durability between cement mortar and lime mortar is considerably greater than their difference in strength. Ours is so cheap that it could profitably be substituted for lime in the mortar for ordinary masonry.

If cement is to be used, it then becomes a question whether Portland or Rosendale should be preferred. If great ultimate strength is required, then Portland cement must be employed; but if a quick-setting mortar is desired, then Rosendale cement must be employed. Unless a quick-setting mortar is required, there is a decided advantage in using Portland, for, as it hardens more slowly, it is not so liable to set before reaching its place in the wall. This is an important item, since with a quick-setting cement any slight delay might necessitate the throwing away of a box of mortar, or the removal of a stone to scrape out the partially-set mortar.

It is sometimes very desirable to have a cement which will set more quickly than Portland, and finally attain a greater strength than Rosendale. Under such circumstances, a mixture of Portland and Rosendale can be used. Such mortar sets about as quickly as if made with Rosendale cement only, and acquires great subsequent strength, due to the Portland cement contained in it. The strength of the mixed mortar is almost exactly a mean between that of the two mortars separately.

If the choice of the cement is not determined by any of the preceding conditions, the question then becomes one of relative strengths and relative prices. For example, an examination of a table of the strength of cement mortars will show that at the end of a month the strength of a neat Rosendale mortar is equal to that of a 1 to 1½ Portland mortar, a 1 to 1 Rosendale is equal to 1 to 3 Portland, and a 1 to 2 Rosendale is equal to a 1 to 5 Portland. The cost per cubic yard of the last two mortars will be about as follows:

Rosendale 1 to 2.		Portland 1 to 5.	
Cement (720 lbs.) 2.40 bbls. @ $1.00	$2.40	Cement (425 lbs.) 1.14 bbls. @ $3.00	$3.42
Sand, 0.84 cu. yd. @ $0.40	.33	Sand, 0.99 cu. yd. @ $0.40	.40
Labor,	.50	Labor,	.50
Total cost of cu. yd.	$3.23	Total cost of cu. yd.	$4.32

This shows, that, under these conditions, the Rosendale, strength for strength, is the more economical.

In conclusion, allow me to mention one little fact, by means of which a mortar may be made impervious to water. Mortar may be made practically non-absorbent by the addition of alum and potash soap. One per cent., by weight, of powdered alum, is added to the dry cement and sand, and thoroughly mixed, and about one per cent. of any potash soap (ordinary soft soap made from wood ashes is very good) is dissolved in the water used to mix the mortar. The alum and soap combine and

form compounds of alumnia and the fatty acids, which are insoluble in water. These compounds are not acted upon by the carbonic acid of the air, and add considerably to the early strength of the mortar, and somewhat to its ultimate strength. With lime mortar the alum and soap has a slight disadvantage, in that the compounds which render the mortar impervious to water also prevent the air from coming in contact with the lime, and consequently prevent the setting of the mortar. On the other hand, the alum and soap compounds add considerably to both the early and ultimate strength of the mortar. This mixture could be advantageously used in the mortar of outside walls, for masonry in wet places, for pointing mortar, for the plastering of cellar and basement walls, for lining cisterns, etc. The efficiency of the alum and soap compounds is shown by the fact that the walls of the Croton reservoir, in Central Park, New York City, were rendered impervious by simply washing them four times alternately with the alum and the soap solutions. Before being coated the walls allowed the water to pass freely. Four coatings,—two pairs,—made a common brick absolutely impervious under a forty-foot head of water.

The use of the alum and soap as above would in all cases greatly diminish, and in most cases entirely prevent, efflorescence or "whitewash," which so frequently disfigures brick walls.

DISCUSSION.

Mr. Bullard.—I would like to ask Prof. Baker if he has had experience with the patented "hard plasters" which are used largely for plastering buildings, and whether this plaster could be used as a cement in masonry.

Mr. Baker.—I have not seen them, and would be glad to learn something of them.

Mr. Bullard.—There is manufactured a substance called "adamant," which is used as a substitute for ordinary plaster on walls. The company now have a factory started in St. Louis. It is made of clay, I believe, treated with chemicals so as to set after application with water, becoming of a stone-like consistency. There is another kind similar to that mentioned. The company is now preparing a plant in Springfield. It is called the "Fitzgerald hard plaster," being made after Fitzgerald's invention. The latter kind is made of lime so treated with chemicals that after being placed on the wall it becomes rapidly hard as stone, and very tough. It can not be easily injured or damaged on the wall, and is a much more desirable wall covering than ordinary plastering. I did not know but some experiments may have been made with these materials in connection with masonry construction.

Mr. Baker.—I would be pleased to have samples of these materials, and will test them, if large enough quantities can be procured.

INTERLOCKING AND SIGNALING.

CHARLES HANSEL, of Springfield.

This is a field of modern engineering, and, although but fifteen years have elapsed since the first system of interlocking was constructed in this country, we have made rapid progress, and in many respects are in advance of other nations in the perfection of our devices.

The subject of interlocking and signaling is at present engaging the earnest attention and skill of our most efficient railway men, and the signal engineer has before him a field full of possibilities, and replete with problems worthy of his best skill.

On the 3d day of June, 1887, the Governor of this State approved an act in regard to the dangers incident to railroad crossings on the same level, or "grade crossings," as it is understood among railway men. This act, in brief, provides, that where two railroads, crossing at grade, shall construct and maintain a system of interlocking and signals at the crossing which shall provide against the possibility of trains colliding at the crossing, then and in that case trains may pass over such crossing without first coming to a stop. Such device must be approved by the Railroad and Warehouse Commission; *Provided, however,* that the said Railroad and Warehouse Commissioners shall have power, in case such interlocking system, in their judgment, shall by experience prove to be unsafe or impracticable, to order the same to be discontinued."

Article 2 of this act provides that the Commissioners may appoint a competent civil engineer to examine such proposed systems and report to the Commissioners.

When we consider the loss of time and the expense incident to the stopping of trains at the thousands of crossings in this State, it is manifest that railroad managers will endeavor to equip their lines with an approved device which will not only be a feature of economy in maintenance, but a factor of safety, speed and comfort to the travelling public.

During the past year it has been my duty to examine such devices for interlocking and signaling crossings, and I am pleased to note that it has been the design of both railway management and the builder of the device to provide the most complete and efficient device known to science, rather than to put in only such device as they think *might* be approved by the Commissioners.

I trust my associates here present will pardon the incompleteness of this paper, as I have had but a limited period of time to prepare the

article, and the field is one in which we may search and study intelligently, and yet not be able to say that we are acquainted with the multiple devices, systems, and manner of the best appliances known for the performance of the important function of safely guarding the traffic of to-day. I will therefore not attempt to lead your attention through all the intricate mechanism of the many devices designed for interlocking, derailing and signaling, but will confine myself to an effort to explain the general requirements of a simple crossing.

England taught us the first lesson in the interlocking of switches. We had upon some of our principal railways a system of train block signals, but no attempt was made to provide a device for the grouping of several movements of switches and signals at a central station or tower, until 1874, at which time the Pennsylvania Railroad brought over a machine from England, and erected it at East Newark, N. J. This machine was built and erected by English workmen, and was known as the "Saxby and Farmer Machine." Many types of machines have been devised since that time, the most common in use being, however, this same Saxby and Farmer, with many additional appliances, making it now one of the best lever machines in use.

The requirements of the interlocking and signaling of a simple crossing are as follows: About three hundred feet each way from the intersection of tracks there is a derail point in one rail, constructed in the same manner as the points for ordinary splits or points switch. Fifty feet beyond the derail is located a semaphore signal, consisting of a post, from fifteen to twenty-five feet high, located on the engineman's side of the track, and about seven feet from the rail, if practicable. Upon this post there is a blade, about five feet six inches long, and ranging from eleven inches at the outer end to seven inches at the arm-grip, or casting connecting it with the post, This blade is movable, and is operated by the target-man in the tower, and is called the "home signal." The blade is generally painted red on the farther face. Twelve hundred feet beyond this "home signal" is located a similar semaphore signal, known as the "distant signal," the blade generally painted green on the farther face.

The target-man is located in a tower, in a convenient angle of the crossing, elevated sufficiently to command a view of trains approaching the crossing on either track. The signals and switches are operated from this tower by levers connected with derails, switches and signals by pipe or wire. The derail and switch movements are by positive motion pipe connections; the "home signals" either by pipe or wire, and the "distant signal" by wire. The derail points are locked to the stock rail by a double-point lock, and the signals are locked on the ground at the switch or derail by two flat iron bars, moving at right angles, one connected with the switch and the other to the signal movement. Each bar is notched so that in their normal position either one is free to move, but the movement of either one locks the other. A thin iron bar, about forty feet long, is hinged to the outside of the line rail at facing point switches, slip switches, derails and movable crossings. This bar is so

hung that it can not be moved lengthwise without at the same time being raised. When the switch is in proper position, either open or closed, the top of the bar lies in the same plane with the top of the traffic rail. It is known as the "detector bar," its function being to prevent any movement of the switch while an engine or car is on the switch. Unless the track is clear, it is impossible to move the switch and split a train, as the bar is operated by the first movement of the lever which operates the switch.

The normal position of all signals is at "danger,"—the arm of the semaphore signal fixed in a horizontal position, and derails open. With this position, should the engineman disregard the signal of danger, as indicated by the blades of the semaphore, and attempt to proceed, the train will be derailed at the open switch, which would prevent two trains coming in contact at the crossing. The "distant signal" is a cautionary signal, and calls the attention of the engineman to the fact that he is approaching a crossing. The "home signal" is a danger signal, and controls one main track movement within its limits.

The machine and ground constructions are so interlocked that the operator must first put derail points or switches in the main track so as to give a clear track before the signal shall indicate "safety." At a single crossing the derail points are operated by a single lever, the movements of both derails being simultaneous. It is also sometimes the practice to operate the "home" and "distant" signals with separate levers. In the latest practice, however, both signals are connected with one lever, which operates at different intervals of its stroke a switch lock and bar and a "home" and "danger" signal. With this preliminary description of the positions and functions of the various signals, derails and other connections, I invite your attention to the tower, from which the movement and direction of all trains is conducted.

The tower is divided into two stories, the lower containing the frame supporting the interlocking machine. The operator's room is provided with glass windows on all sides. In front of the operator is placed the levers and interlocking machine, the levers in a line numbered to correspond to a diagram placed in view of the operator. The levers are grouped so as to be most convenient to the operator, the signal levers being arranged on the side nearest to the signal controlled by it. The levers are genarally painted as follows: Switch lever, black; lock lever, blue; "home signal" levers, red; "distant signal" levers, green; combination lock and signal, half blue and half red.

All signals being at "danger," as before stated, the engineman of an approaching train gives the required call for crossing by an agreed number of blasts from the whistle, calling for a clear track. The operator in the tower pulls the switch lever operating the derails on the track called for by the engineman. The act of reversing this lever, through the interlocking of the machine, first withdraws the locking pin from the lock rod and raises the detector bar above the level of the rail, then moves the switch to "safety," and forces the lock bolt through a second hole in the locking rod, restoring the detector bar to its normal

position below the level of the rail, at the same time, and releases or unlocks the signal lever. The track is now clear, and the signal lever is then reversed, moving first the "home" and then the "distant" signal to "safety," inclined at an angle of seventy-five degrees to the horizontal. The final movement of the signal lever home, locks the switch in the tower and on the ground, and gives clear signals for the approaching train. After the train has passed, the signal lever must first move the signals to "danger" position before the switch lever is free. This is done, and all the levers returned to normal position.

All levers in a machine are pivoted on one common center, and each identical in construction and operation, the foundation being separate from the tower. In front of the levers is a cast-iron frame containing movable locking bars. These bars are moved by an iron casting, having the appearance of a gridiron, rectangular in shape, and moving in bearings in front and rear secured to an iron frame. This is known as the "flop." This "flop" is connected with a radial link by a universal joint. The lever is connected with this radial link with a pivot block secured to one side of the main lever. During the movement of the lever the pivot block travels in the radial link, moving it vertically, which, in time, moves the "flop," which strikes a "dog" attached to the locking bars, driving it sufficiently to lock all opposing levers and free the lever next in order to be operated. Without illustrations of parts I will not attempt to detail the combination further.

The expansion and contraction of metal by variation of temporature is a fixed law of nature. This fact has made it necessary for the signal engineer to provide some method of compensation in the long lines of wire pipe which it is necessary to use. The "Lazy Jack" compensator has been designed to overcome this difficulty. With this compensator two bell cranks are pivoted to a foundation and connected with a bar. The pipe is connected with the two outside ends of the bell cranks. This "Lazy Jack" is located midway on the line of pipe, and as each section of pipe expands or contracts equally, one end of the lever will be moved in one direction, and the other end in an equal distance in the other direction. The pipes are carried on rollers fixed in castings, and the whole boxed to prevent displacement or freezing. The signals being generally operated by a front and back wire, one to lower and the other to raise the signal, it is not necessary to compensate.

In early practice, when a signal was returned to normal position by gravity, and a single wire was used, it was necessary to use a compensator to prevent movement of the signal by reason of the changing of the tension of the wire during varying temperature.

When it is impossible to have a throw-off or derail switch on siding, a block of iron, triangular in shape, known as a "Skotch Block," is thrown up on the rail. The purpose of this block is to derail the engine or car, should they pass the signal.

Although there are many other designs of machines calculated to perform the functions of complete interlocking, they differ in the machine described only in the application and arrangement of the locking, and

the results to be obtained must be practically the same in each. I will not attempt further description, but will name a few well-known types: The Union Switch and Signal Company, the Hambay, Stevens, the Wheel Machine, the Johnson, National Switch and Signal Company, and many others.

DRAW BRIDGES.

The law of 1887 did not provide for the interlocking of draw-bridges. I am satisfied, however, that it is a matter of safety to the public that draw-bridges should be interlocked with tracks leading on to them. At Bridgeport the Union Switch and Signal Company are constructing a system of interlocking. There are two gauntlet tracks crossing a draw-bridge which spans the Chicago river. The connection with the bridge and track interlocking is performed by a multiple coupler, so designed that all signals and switches are locked immovable before interlocking can be disconnected at draw and bridge swing. The connection at the bridge is made by a hook and eye machine, and all the hooks must be in line before the eye bars can be raised, and it is impossible to have a clear signal on the track approaching the bridge while the draw is disconnected. All foundations for chain throws, bell cranks, "Lazy Jacks," compensators, pot signals, pipe-carriers and wire-carriers should be firmly placed in the ground, and the points subjected to special strain should be cemented in place.

Probably the most ingenious device that has been constructed to economize space and cheapen construction and maintenace of a complicated interlocking plant, when there is a number of tracks and routes to be controlled, is the machine known as the "Selector Indicator." At points where a number of routes lead off of a single track it was formerly the practice to signal each of the several routes by separate blades. This is an expensive and confusing method, and has been overcome by the skill of the signal engineer in the production of the "Selector Indicator." With this system but one post and blade is used. Directly below the blade, on the same side of the post, are pivoted a number of small levers. Upon the top end of each is fixed a disc of sheet-iron about fifteen inches in diameter. These discs have cut out of them a number corresponding to the number of the route that it controls. The disc is painted black, and has a piece of ground glass attached to the back, which shows the number white by day, and illuminated by night by a lamp, making the figures distinct in contrast to the black ground. These discs normally rest behind a screen, and are worked simultaneously with the blade by separate connections with the switch it indicates. When it is desired to manifest a clear route, the switches governing it are cleared, which movement lowers the blade and throws into view the disc, showing the number of the route selected. The disc is not to be considered as a signal, but operates with the signal blade to indicate the route which is clear for traffic. As these discs are not discernible for long distances, they should be used only in connection with slow-speed

trains. Dwarf and pot signals are used in yards for shifting or drilling movements. These are built in many forms,—generally to conform as nearly as possible to the accepted semaphore pattern.

PNEUMATIC SYSTEM.

The application of compressed air for the movements of switches and signals, in connection with the electro-magnet, controlled by an electric current, and operated by a man in a tower, possesses many advantages over the manual machine first described.

The normal position of the signal is at "danger," when the current is broken, it being impossible to operate the switch or signal until the current is closed and the proper position of the signal is announced in the tower. A miniature model of the switches and signals controlled is connected with the machine, directly in front of the operator, and each movement made in the yard is plainly indicated thereon.

The Pneumatic system is furnished with a steam generator in a cabin, which supplies power to the air compressor. The air is carried to auxiliary reservoirs, one at the bottom of each signal post. Lateral pipes connect with the operating cylinders, which actuate the switch movement. The pressure sustained is from sixty to eighty pounds. The valves of the cylinders are moved by an electro-magnet; the signals are held in "danger" by a counter weight; it is therefore manifest that any interruption of the current places the signal at "danger," and as all levers are interlocked in the tower, insures safety, as two conflicting signals can not be set at "safety" at the same time.

With this machine one man can accomplish the work of three men on a manual machine, and that, too, with less effort. The levers are easily moved by six to eight pound pressure, and so compact that but little space is occupied in the tower.

A miniature signal is also placed in plain view of the operator in the tower, which displays on a disc the words "blocked," "open" or "locked," as the application is desired. This is called the "Rotary" indicator, and is of great value to the operator.

THE UNION SWITCH AND SIGNAL CO.,

SWISSVALE, PA., *Jan. 22, 1890.*

CHAS. HANSEL, ESQ.,
Consulting Engineer, R. R. & W. Commission,
Springfield, Ill.

Dear Sir:—In reply to your inquiry as to the number of interlocking machines in use in the United States, and also in the State of Illinois, would say that we sold and erected 551 interlocking machines in the United States, 52 of which are in Illinois.

These interlocking machines are made up of wheels and levers, there being a total of 7360 in the United States, 663 of which are in Illinois. Of the total of 7360, 280 are wheels, 56 of which wheels are in Illinois. This leaves a total of 7080 levers in the United States, 607 of which levers are in Illinois. The lever machines are divided as follows:

6046 Saxby & Farmer levers in the United States, 500 of which are in Illinois; 470 Stevens levers in the United States, 3 of which are in Illinois; 46 Toucey & Buchanan levers in the United States, none of which are in Illinois; 68 horizontal levers in the United States, 8 of which are in Illinois; 110 hydraulic levers in the United States, 80 of which are in Illinois; 264 Westinghouse pneumatic levers in the United States, 6 of which are in Illinois; 13 crank levers in the United States, 10 of which are in Illinois; 4 Hambay levers in the United States, none of which are in Illinois; 59 ground levers in the United States, none of which are in Illinois,—making a total, as above stated, of 7080 levers in the United States, and 607 of which are in the State of Illinois.

This list only includes the interlocking levers, and not those that are used for working block signals.

I think this will give you the information required. Should you need anything further, I will gladly furnish it.

Yours very truly,

THE UNION SWITCH & SIGNAL CO.

By HENRY SNYDER, Gen'l. Manager.

Many other safety devices are provided, which lack of space will prohibit mention of. The system of hand, switch and train signaling is, in my opinion, far behind the complete mechanism of the interlocking system. There is a great need of uniformity in the design and government of signals intended for like duties. As now used, each railway has a different code, one often being essentially conflicting with the other. With most of the codes now used the manner of signaling changes at sunset and sunrise. By day the form of signal governs; by night the color of the light is the only guide. Form should govern by night as well as by day. The Koyl parabolic semaphore signal claims to fill the requirements of an illuminated blade by night. The Union Switch and Signal Company also furnishes an illuminated blade for semaphores. This feature should be made a part of all signals. It is an element of safety vital in its results. Too much stress can not be laid upon the importance or a position signal. Form is easily distinguished when color is not discernible even by the keenest eye; and many of our most careful engineers can not determine color, who could easily determine form.

All signals should show a form for "safety" as well as "danger." It is the practice on some railways to indicate but one position, and that for "danger." Is it not apparent, that if but one form of signal is used it should display at "safety?" For should the signal be destroyed, the signal to advance would not appear, and the train must stop for the "safety" signal to be shown, whereas, if the position was given for "danger," only, and the switch be displaced and the signal destroyed, no signal of danger appearing, the engineman would proceed, and bring destruction to his train. I think the use of the torpedo is misapplied on many roads; for instance, the rule as follows: "Explosion of one torpedo, Proceed under control; explosion of second torpedo, Stop, danger." Let us suppose the second torpedo does not explode as intended,

or, perhaps, is displaced, then, under the rule, the engineman would proceed to danger when he should stop. The torpedo should be used as follows: Explosion of one torpedo, Apply brakes to stop; explosion of second torpedo, Proceed at caution, train under control. This would provide against the fault of the first rule mentioned, which is now in use on some roads.

Station order boards should give two forms as well as *all* other signals. Train-men should be provided with a book, of convenient size, in which is shown the position of signals to be used on engines and cars under each movement of the train possible under the rule; also the form and use of all signals to which his attention is called while running. Each diagram should be followed by a short rule, so plain and direct as to be impossible to misconstrue its meaning.

The automatic block system, whether operated by electricity alone or by the combination of electricity and compressed air, has been perfected to such a degree that its adoption by railway managers is only limited by the expense.

In the block system the automatic rail current is used. A Gravity battery supplies a sufficient current to operate the signals in the block, if assisted by compressed air. The current is carried by the rails, being connected at the joints by wires connected to each end of the rail. The insulation between the blocks is made by placing a wooden washer between the angle bar and the rail, and between the ends of the rails. The sections blocked may be of any length convenient to the traffic to be controlled. At the termination of each block a semaphore signal with two blades is generally provided, especially on short sections. The upper blade indicates "danger," the lower, "Proceed under control."

The normal position of all signals is at "danger,"—blades horizontal. The cessation or interruption of the current places the signal at "danger." When a train enters a "block" the current is taken up through the wheel and axle to the opposite rail, the first signal post goes to "danger." When the train leaves the first block and enters the second block the upper blade on the first post passed is lowered by the completion of the current or circuit. The lower blade remains at "caution," indicating to the train following that the first train is in the first block ahead. When the first train passes off the second block the lower blade of the first signal moves to "safety," and the second train may proceed at full speed.

The simplest system in use makes the telegraph station the terminus of the blocked sections. This requires an operator at each station, whose duty it is to notify the stations on each side when a train has cleared his station.

The question of the adoption of a uniform code of signals has been the subject of much debate among thinking men who are charged with the safe government of the transportation of persons and property. The rapid advance in the perfecting of signals adds to the difficulty of determining upon a system which should be adopted as a universal standard. This fact should not deter us from investigating the best appliances

known to science, and adopting the most efficient. To this end I would suggest that a congress be called by the railway managers, each company to be represented by a person conversant with the methods of signaling in use on the line he represents. A careful consideration of all methods would enable this congress to select the most efficient, and complete a code which should be the accepted code on all railways. This congress should be permanently organized, and annual meetings held to consider any new devices that may be offered for the improvement of the code.

Changes from established methods should be well considered before recommended, as the expense of radical changes is an item which should not be over-looked. Railway managers who have won position by faithful and intelligent labor, guarding alike the interest of the public and the property in their charge, wisely hesitate to adopt new methods which have not been thoroughly tested by practice. Yet these same men with the clear insight into the multifarious necessities of the successful conduct of the business in their charge, are the first to acknowledge the necessity of guarding every point of danger. At all times, and during all seasons, by day and by night, their energies are employed in directing the affairs of their respective offices. Look at the results. In sixty-four years we have arisen from the tedious travel by the stage coach or "prairie schooner" to the luxury of the palatial vestibule train, whose passage over bridge, highway crossings, opposing railways and through tunnels is made safe by the efficient safeguards of to-day.

DISCUSSION.

Mr. Baker.—There has been greater advances made in interlocking and signaling in the last three years than in any other branch of engineering. In fact there has been called into notice a class of men called the signaling engineer.

ALTERATIONS IN WASHINGTON STREET TUNNEL.

S. C. COLTON, of Chicago,

It has been suggested to the writer that the members of the society would be interested in the repairs being made upon Washington street tunnel for the admission of the West Chicago Cable Railroad.

Engineers are, as a body, a very communicative class of men, always telling what they know, and suppose no one else knows, for the benefit of mankind. The writer hopes he is no exception to the general rule.

The tunnel under consideration runs from Franklin street, on the South Side, to Clinton street, on the West Side, a distance of some fifteen hundred feet.

During the incumbency of Mayor Harrison this tunnel was given to the Chicago Passenger Railroad, and lately, Charles T. Yerkes, by the purchase of the stock of this road, has come into possession of the tunnel.

It was necessary to make extensive repairs to the structure in order to make it passable for cable cars. Ever since the construction of the tunnel, in 1867 and '68, it has been in bad condition, always leaking more or less, and for the last year or two has been abandoned for teaming. The foot passage has been in better shape, and has remained in constant use up to the time that the Fitzsimons & Connell Company undertook the work of repairing the tunnel in August last.

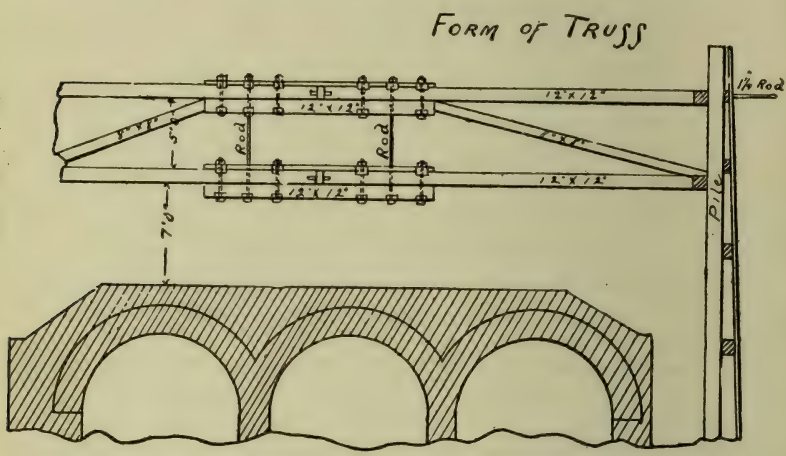
As soon as Mr. Yerkes came into possession of this tunnel, and spoke of repairing it and making it passable to the public, the marine interests stepped in and said that lake navigation needs more water in the river, and, consequently, the roof of the tunnel must be lowered three feet, giving them seventeen feet, instead of as at present fourteen feet, of water below city datum, which is the surface of the average water at the present condition of things.

This constituted the difficulty of the work in question. The river had to be coffer-dammed, and at a time when there was considerable traffic yet moving in the stream, and so but one-half of the river could be closed at once.

It was decided to bring the old Madison street bridge down to Washington street, and place it on piers, for use at that thoroughfare. Thus the piers for the bridge must be built at the same time that the tunnel was being repaired.

For the center pier of our bridge we built a crib of 12x12 pine timber, thoroughly drift-bolted, and sunk it in mid-stream directly upon the flat roof of the tunnel. This crib was 30 feet by 40 feet, and divided into five compartments by solid walls of 12x12 pine. It was placed with the 30-foot dimension on the center line of the tunnel, and served the double purpose of center pier and end of the coffer dam.

The dam was built by driving two rows of 35-foot piles, four feet apart in the outside and three feet in the inside rows, from the ends of the above crib to the shore, making a dam about one hundred feet long.



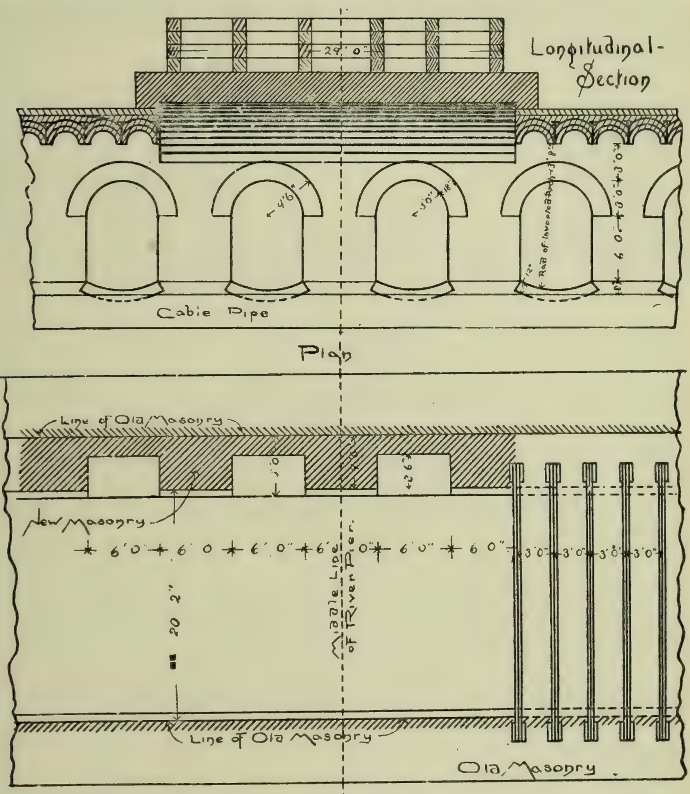
After placing four mud-sills on the inside, and three on the outside rows of piles, twenty-four foot three-inch of oak plank was driven for sheeting, and in some places, where the sills were not well placed, we drove 6x12x24 oak for sheeting. Between the rows of sheeting good tough clay was puddled, the clay being dredged on the spot and thrown into the dam by the dredges.

The bracing inside the dam was quite novel. The clear span of the opening was fifty feet, and we used two pieces of 12x12 pine, either twenty-four or twenty-six feet long, in pairs, clamping them in the center to a 12x12 pine, sixteen feet long, by heavy iron clamps passing over the two sticks, and a three-inch oak on top. These struts were held up by strain beams, and carried angle-bracing from the middle points of the panels. These trusses were spaced fourteen feet to the center, and there were two struts, the lower one suspended from the upper one, and about five feet between timbers.

This system left the space below the bottom brace entirely free from posts,—a great advantage in construction.

We had quite a little trouble in first pumping out our dam, but once pumped down and all leaks stopped, an old centrifugal pump which had been in service since the building of the tunnel was all that was necessary to keep the dam dry for the remainder of the work.

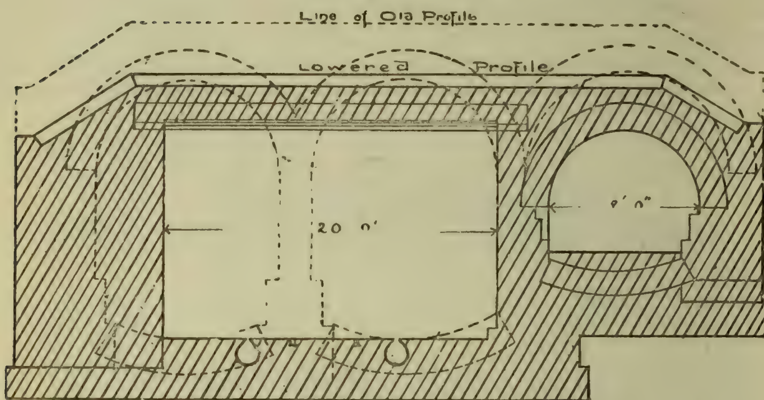
As regards speed in the work, let me say that on December 24 we started to tear up the east half, (which must be done before the west half could be begun,) and on January 15 the water was out and we were at work on the roof of the west half. When once a dry dam was obtained the remainder of the work was comparatively easy, excepting that the material to be removed was exceedingly hard, and required blasting.



Nearly all the work was laid in Portland cement, and was in excellent condition. The old roof was composed of a twelve-inch course of limestone flagging on the outside, next being about one inch of rock asphalt, then the five-ring brick arch, with the haunches filled with concrete and rubble-stone masonry. The roof at the key of the arch is about thirty-six inches thick.

The section of the tunnel under the river has heretofore been a double arch resting on a center wall, leaving two openings, of ten feet each. The old section, as far as the river, has not been changed, but under the river the two arches have given way to a flat roof of steel girders, twenty-four feet long and twenty inches high, connected by three-ring brick arches.

River Section



The beams are placed thirty-six inches to centers, and the arches have a rise of eight inches, with the two inner rows laid in English Portland cement, and the outer one in asphalt. Directly under the center pier an arch, [not shown on the drawings.] span twenty feet six inches, rise six feet six inches, is substituted for the beams, very little of the old work being removed, as the arch is turned inside the old one. Thus we have the two openings changed to one clear opening twenty feet six inches by twelve feet six inches high, above track level.

The covering above these steel beams is ten inches of English Portland cement concrete.

There is no possibility of a loaded vessel ever landing its weight on the flat roof, as the center of the span is slightly concave, and thus whatever rests on the roof is thrown onto the side walls.

Throughout the entire length of the tunnel runs a five-ring brick inverted arch, leaving under the river, when the roof is lowered, only ten feet in the clear.

The head room required for the cable cars is twelve feet six inches above track. Thus the whole surface must be lowered two feet six inches, and the cable conduit placed below this.

This arch is hard sewer brick, laid in Portland cement, and is anything but an easy task to remove. We have used dynamite almost entirely, as hand-chisels and picks make no headway at all. There must be removed from the tunnel some two thousand five hundred cubic yards of old brick and stone masonry.

You will notice on the plans a wall on the left. This was just in place before the roof was removed, and while the dam above was being constructed.

The alterations in the foot passage consist of turning a new arch inside the old one, and does not present any difficulties.

LEDLIE'S PROPOSED SEWERAGE SYSTEM FOR JOLIET—DESCRIBED FROM REPORT, MAPS, SPECIFICATIONS, ETC.

F. W. HAWKS, of Joliet.

The survey for the sewerage system for Joliet was begun in February, 1889, and the plans submitted in May: It consists of a report, a contour map, scale, one hundred and fifty feet to the inch, with contour lines a foot apart, profiles of the five trunk lines, plan and section of man-hole, map of territory where it is proposed to take care of sewage; five plats, showing pumping station, settling basin, filtering beds; five specifications,—first, the manufacture of pipe and specials; second, excavating, backfilling, laying, etc.; third, settling basin and filtering beds; fourth, buildings; fifth, engine and boilers. From these I have taken what I thought would be of general interest, not attempting to give a complete description.

Joliet is a city of 30,000 inhabitants, situated thirty-seven miles south-west of Chicago, on the Desplaines river and Illinois and Michigan canal. The most thickly populated part of the city is included in four sections which corner near the principal business portion of the city. In this description we will consider the city as a square two miles on a side. Running across this square, from the north, in a southerly direction, are three water-courses: First, the river, with the canal; second, Hickory Creek, and its tributary, Spring Creek; and third, the slough drain. The river and canal enter the city near the center of the north line, and leave at the south-west corner, during which the fall is about twenty-five feet. The creek water-course enters at the north-east corner and leaves at the center of the south line, with twenty-three feet fall. The slough drain drains a low part of the city midway between these two, with about nineteen feet fall. The trunk lines of Ledlie's proposed sewerage system follow these three courses.

The city west of the river rises, with bluffs and steep grades, to one hundred feet above the river. The east side is of a comparatively low grade, of ten feet rise. The lowest point is on the line where the river leaves the city limits. It is at this point where it is proposed to take care of the sewage. Beds of limestone, from the surface to various depths, covered with soil and considerable gravel, extend as foundation over a large part of the city.

The area of the city being a little over two thousand five hundred acres, not closely built up, and few streets being paved and guttered,

and requiring heavy initial outlay for large conduits through rock, the "separate" system is advised. Another important factor in selecting the "separate" system is the method of final disposal. The fact that means are being considered for the abatement of the nuisance arising from the present condition of the Desplaines river from Chicago sewage makes it necessary to consider methods other than conducting sewage to the nearest water-course; and whatever means of improving the river are adopted, it is not to be supposed that Joliet, even should she so desire, will be allowed to discharge crude sewage into it. For if the city of Chicago should purify its sewage before allowing it to enter the river, the same would be required of Joliet.

Of the six methods by which it has been proposed to treat sewage of the water carriage system, viz., mechanical filtration, subsidence in tanks, broad irrigation, intermittent filtration through land, chemical precipitation, and chemical precipitation and intermittent filtration combined, the last, which is a combination of the fourth and fifth processes, offers, in Mr. Ledlie's estimation, the best method for permanent disposal in Joliet, as the large amount of limestone in the vicinity furnishes the necessary lime cheaply for the chemical process, and thus, all solids having been removed, the filter beds need occupy only a small area, which is found near the river, at its lowest point.

Mr. Ledlie proposes to collect the sewage at a point near the river, just below the south city limits, by five trunk sewers, namely, (beginning at the west) Center street line, Bluff street line, East side of river line, Slough drain line and Hickory creek line. The depth of these trunks is such as to receive the sewage of the above described territory with but few exceptions. The excepted districts can be raised sufficiently to allow them to drain into the proposed trunks at less cost than would be entailed by deepening the trunks the necessary amount through their entire length, and which would cause an increase in the annual cost of pumping. The grades are such as to give a velocity of not less than two and a half feet per second in all sewers when running half full, and the depths such as to allow the same velocity to be maintained in all the laterals, which are recommended to be not less than eight inches in diameter.

With these grades all necessary flushing can be done by making connections, by means of rubber hose, through the man-holes, with fire hydrants. The ventilation of the sewers is provided for by man-holes placed at all intersections and changes of grades. All the laterals enter at man-holes on a curve, to which the trunk is tangent.

By trunks, the sewage will be collected in a pump pit about twenty-six feet below the surface of the ground, at the pumping station, located near the river, at the south city limits; thence it will be pumped to the settling basins, the chemicals having been added at the pumping station. The solids are precipitated, and the "clarified affluent" passed on to the filter beds, from whence it drains into the river. The "sludge" or solid matter thus precipitated, still containing about ninety per cent. of water, is drained to the press room, where, by means of proper presses, about

fifty per cent. of water is removed, rendering the "sludge" compact enough to be easily handled. It may then be dug into the ground, burned under the boilers at the pumping station, or disposed of as other city garbage. The principal chemical to be used is the milk of lime, and a small amount of sulphate of ammonia, if found necessary. The exact amount of chemical must be determined by experiment.

The settling basins will be six in number, and have a capacity of 450,000 United States gallons each, and will be located about five hundred feet from the pumping station. It is proposed to build three set-settling basins at present, others being added as required. The filter beds, having an area of one acre to five thousand people contributing sewage, must be made of gravel, to be found in the vicinity, and under-drained. These drains, at the outlet, are to have an elevation of about five feet above surrounding land, which assumes that the flood shall not rise higher than that elevation. The area will consist of several divisions, and the influent pipes so arranged as to allow each section to be used intermittently.

Since all sewage has to be pumped, the advantage of entirely excluding ground water is evident. Experience having shown this to be impossible with tile pipe and cement joints, therefore coated cast-iron pipe, with lead joints, is recommended. Pipe sections, in length over all to be twelve feet, four inches, and with bell and spigot, coated inside and out with pitch varnish, and a tensile strength of at least eighteen pounds per square inch. The pipe is to be laid on earth filling six inches deep, exclusive of rock, and covered to a depth of eighteen inches from top of pipe with the same material, then with material excavated.

Inlets and man-holes are made with rubble masonry,—the bottom of concrete, made in the proportion of one-fourth of a barrel of cement, three-fourths of a barrel of sand, and one and one-fourth barrels of clean, hard limestone, broken to not exceed two inches in diameter. Total diameter of top, including masonry, four feet. Diameter of cover, twenty-two inches.

The Center street line drains the extreme western and high part of the city. It begins with a ten-inch pipe seven feet below the surface, with a minimum grade of 1.211, continuing four thousand feet, where it falls perpendicularly ten feet, and joins the Bluff street line. Its last half is through a large per cent. of rock, about five feet in thickness, Its total cost to this point is $8840.

The Bluff street line follows the west side of the river, beginning with a ten inch pipe. Its average depth is seven feet, with considerable rock. Grade 1.300. At the end of five thousand nine hundred feet, and eighteen feet below the surface, it joins the Center street line. Cost to here is $16,500. The united trunk continues, with fourteen-inch pipe, nine hundred and eighty feet, to the river. As the purifying works are on the east side of the river, it becomes necessary at this point to take the pipe under the canal and river. Though side by side, the bed of the canal is here ten feet higher than the bed of the river. The crossing is made by means of a tunnel under the canal and an excavation in the bed

of the river. Within a large man-hole the pipe drops to twenty-five feet below the surface; thence, through the tunnel at a grade of 1.13, to another man-hole; thence, through the bed of the river. The lining of the tunnel is to be rubble masonry or hard-burnt brick. It is four feet wide, five feet high and two hundred and twelve feet long. Estimated cost, including pipe and man-holes, $5150. In four hundred feet after the line leaves the river it joins the East side of the river line.

The East side of the river line follows the river, with a ten-inch pipe, through rock, with a minimum grade of 1.300 for nine thousand, one hundred and fifty feet. Here it is joined with the Slough drain line. It continues, with eighteen-inch pipe, grade 1.500, six hundred and fifty feet, then joins with Hickory Creek, the line continuing, with twenty-four-inch pipe, to the pumping station. Its last grade is 1.650, and twenty-six feet below surface at the station. The total cost of this line is $61,260.

The next line to the east is the Slough drain line. Its sections are: First, four hundred and fifty feet of ten-inch pipe, at moderate depth, grade 1.300; second, four thousand feet of twelve-inch pipe, grade 1.350, average depth twenty feet, mostly rock; third, three thousand five hundred feet of fifteen-inch pipe, grade 1.400. The total cost or this line is $72,500.

The fifth trunk line is the Hickory Creek line. It drains the extreme eastern part of the city. Its sections are: First, eighteen hundred feet of ten-inch pipe; second, four thousand feet of twelve-inch pipe, grade 1.350; third, three thousand feet of fifteen-inch pipe, grade 1.450; and fourth, four thousand feet of sixteen-inch pipe, grade 1.500.

This line has comparatively no rock during its entire length. Provision has been made in this line for taking the sewage of five thousand people north of the city limits, and also for a like number on the east side of the city limits. It is necessary that the man-holes along this line be made tight, to insure the sewage against being flooded by high water.

The elevation of the trunks west of the river is such, that if so desired, the sewage can be turned into the river; but from the east side it would still have to be pumped. It is not likely, however, that while our river remains in its present almost unbearable condition that the city will make any very large appropriation for purifying its own sewage.

THE TOTAL COST OF WORKS.

Trunk lines	$250,000
Settling basins, (complete)	25,000
Filter beds	6,500
Buildings	48,000
2 Three-million gallon pumping-engines	49,000
Sludge-press and mixing machinery	10,000
Engineering contingencies, (five per cent.)	19,000
Total cost	$407,500

Annual cost of chemical treatment of sewage for a population of 30,000, (3,000,000 gallons per day) $20,000.

DISCUSSION.

Mayor Clark.—Is the $20,000 named simply for purification of the sewage?

Mr. Talbot.—Yes, Sir.

Mayor Clark.—Why does Joliet need such an expensive plant for separation, precipitation, etc., when it has a natural water-course like the Illinois river to drain into?

Mr. Talbot.—They evidently do not want the city of Chicago to say, "You are doing no better than we are."

Mr. Wightman.—The time is near when such systems must be introduced, for the Illinois river shows strong evidences of pollution at Peoria at present.

Mr. Talbot.—In the Illinois river it is proposed in the Chicago drainage scheme to supply a volume of water that will insure a current, and it is the belief that the Illinois river is bound to be the channel for Illinois sewage, diluted by large volumes of water and a large water-way.

ELIMINATION OF LOCAL ATTRACTION IN SURVEYING WITH THE MAGNETIC COMPASS.

IRA O. BAKER, OF CHAMPAIGN.

[Presented as a discussion of Mr. Davison's preceding paper. The writer of this article discussed the preceding one briefly and impromptu at the meeting, and asked permission to present a written discussion later. See page 37.]

As the writer of this understands it, the preceding paper describes a method of surveying which reduces the errors due to local attraction, by averaging said errors. In the present paper it is proposed to outline a method of surveying which entirely eliminates all local attraction. This method is applicable either to mine surveys or to ordinary land surveys; but as the preceding paper related to mine surveys, they will be considered first.

MINE SURVEYS.

Generally a survey of a mine is made to determine the relative position of the under-ground workings, and the boundary lines of surface property. Consequently it is necessary to find in the mine, first, a point

directly under a known point on the surface, and, second, the direction of a line corresponding to a known line on the surface. The first can be found by means of a plumb-line, or its equivalent, and the second can be found by the use of two plumb-lines, or by a transit,—usually the former. Apparently, the attempt is sometimes made to determine the direction of the underground line by reading a magnetic compass at the mouth of the shaft and again at its bottom. This method is inaccurate if there is local attraction at either the mouth or bottom of the shaft. For the present it will be assumed that the true direction of the initial underground line is known.

For the sake of illustration, assume that a survey is to be made, starting from some point, say A, on the line whose direction is, say, S 78 deg. 10 min. E. Then set the compass at A, and also at each corner or section of the survey, successively, and read the bearing of the two lines meeting in each station. Call the sight made in the direction in which the survey progresses a "fore-sight," and that made in an opposite direction a "back-sight." Keep one end of the box front on fore-sights and the other end front on back-sights. But if one sight of the compass consists of a slit and the other of a hair, the same end must necessarily be kept next to the eye; therefore, read the letters from one end of the needle for fore-sights, and from the opposite end for back-sights, but the degrees from the one end all the time. When all the bearings have been taken the record will be similar to the first three columns of the following table, with the exception of the small figures written above such bearing, which will be explained presently:

TABLE I.

STATION.	BACK-SIGHT.	FORE-SIGHT.	CORRECTION.
A	78 10 S 78° 00′ E	16 05 N 15° 55′ W	10′ B
Q	16 05 N 16° 45′ W	80 30 N 81° 10′ W	40′ F
S	80 30 N 80° 05′ W	46 10 S 46° 35′ W	25′ B
U	46 10 S 46° 35′ W	83 00 S 82° 35′ E	25′ B
V	83 00 S 82° 25′ E	78 00 S 77° 25′ E	35′ B

As explained above, the true bearing of the initial, or reference line, is S 78 deg. 10 min. E. Hence, if there had been no local attraction at A, the back-sight at that station, *i. e.,* the bearing of the reference line, would have been S 78 deg. 10 min. E. But it read, S 78 deg. 00 min. E., and hence there is a local attraction of 10 min. Therefore the bearings taken at A are in error 10 min. The needle read, S 78 deg. 00 min. E, but if there had been no local attraction the needle would have read,

S 78 deg. 10 min. E., therefore the true reading is 10 min. farther from the south toward the east than the observed reading, and hence, to get the true bearing the needle should be moved 10 min. in a direction from the south towards the east. The fore-sight at A is N. 15 deg. 55 min. W.; but to get correct bearings at this station, we must, in imagination, move the needle 10 min. in a direction from the south towards the east, which is the same direction as from the north towards the west, and hence, the correct bearing of the line starting from A is N. 15 deg. 55 min. W., *plus* 10 min. = N. 16 deg. 05 min. W.

For simplicity of explanation, let us call a direction from the south towards the east *backward,* and the opposite direction *forward,* these terms being assigned to agree with direction of the motion of the hands of a watch. It maks no difference in this matter whether we consider N., S., E. and W. in their true relations, or in their reversed position as given by the face of the compass. We will assume them to be in their true relations, and briefly say that the correction at A is 10 min. backward. This is the correction which is to be applied to the fore-sight at A, and is written in the column headed "correction." The standard bearing of the initial line is written over the back-sight taken at A, and the corrected fore-sight is also written above the fore-sight observed at A.

At Q the back-sight, *i. e.,* the bearing of the line from A towards Q, is N. 16 deg. 45 min. W, but the true bearing is N 16 deg. 5 min. W, as found for the corrected fore-sight at A, and hence the error at Q due to local attraction is 40 min. The correction at Q is therefore 40 deg. F, and the corrected fore-sight is 80 deg. 30 min. The corrections and corrected bearings for the other stations are found in a similar manner.

As is easily seen, when the true bearing of the initial line is known, this method absolutely eliminates all local attraction. On the other hand, if the true direction of the initial line is not known, this method will give a fairly good determination of the true direction of the initial line. To do this set the compass at each station, and read the back-sights and fore-sights at each as in the preceding case. The record will then be as in Table II, except for the small figures above the bearings.

TABLE II.

STATION.	BACK-SIGHT.	FORE-SIGHT.	CORRECTIONS.
A	78 10 S 77° 50′ E	16 05 N 15° 45′ W	20′ B
Q	16 05 N 16° 35′ W	80 30 N 81° 00′ W	30′ F
S	N 80° 30′ W	S 46° 10′ W	0
U	S 46° 10′ W	S 83° 00′ E	0
V	S 83° 00′ E	S 78° 00′ E	0
W	78 00 S 78° 10′ E	85 35′ N 85° 25′ E	10′ F

Notice that the fore-sight at S agrees with the back-sight with U, and also that the fore-sight at U agrees with the back-sight at V. Therefore it is extremely probable that there is no local attraction at these three stations, and hence the correction at these stations is O. To find the correction at Q, write the back-sight at S above the fore-sight at Q, and take the difference between the observed and the true fore-sight. This difference is 30 min., and is the correction at Q. A moment's reflection shows that this correction is "forward," as marked. The remaining bearing at Q and the two at A may be found as already explained; and similarly for those at W,—that is to say, the bearings in the upper part of the table are corrected by working backward from S, and those in the lower part by working forward from V.

It may happen that not even two successive stations are found at which the corresponding back-sight and fore-sight agree. When this occurs, assume, *for temporary purposes,* that the correction at the first station is O, and correct all the bearings accordingly. The result will be as in table III.

TABLE III.

STATION.	BACK-SIGHT.	FORE-SIGHT.	CORRECTIONS.
A	S 78° 00′ E	N 75° 55′ E	0
P	75 55 N 75° 35′ E	80 20 N 80° 00′ E	20′ F
R	80 20 N 80° 10′ E	85 30 S 85° 40′ E	10′ F
T	85 30 S 85° 50′ E	88 50 N 88° 30′ E	20′ F
X	88 50 N 88° 20′ E	78 00 S 78° 30′ E	30′ F
Y	78 00 S 78° 20′ E	85 20 N 85° 00′ E	20′ F

Notice that there are three stations at which the correction is the same, *i. e.,* 20 deg. F. This indicates that the apparent local attraction at these stations is the same; it is therefore probable that the needle had its normal or natural position at these stations, and that the local attraction was confined wholly to the other stations. If this argument be correct (its validity will be examined farther presently), then the correction at P, T and Y is zero. By inserting this correction at these stations, and correcting the notes as explained above, we get Table 1V, which gives the *most probable* bearings of the several lines.

For the preceding illustration the argument is slighly defective, since the agreement of the corrections at only three stations might possibly be due to an accidental agreement of the local attraction at these

TABLE IV.

STATION.	BACK-SIGHT.	FORE-SIGHT.	CORRECTION.
A	78 20 S 78° 00′ E	75 35 N 75° 55′ E	20′ B
P	N 75° 35′ E	N 80° 00′ E	0
R	00 N 80° 10′ E	85 50 S 85° 40′ E	10′ B
T	S 85° 50′ E	N 88° 30′ E	0
X	88 30 N 88° 20′ E	78 20 S 78° 30′ E	10′ F
Y	S 78° 20′ E	N 85° 00′ E	0

stations, If this is the case, then it is impossible by this method to find the true bearings of the lines, unless proportionally more stations can be found at which the apparent local attractions agree. For example, if the next five stations give an apparent local attraction agreeing with that found in Table III, for X, then those stations must be regarded as having the normal position of the needle, and the bearings of the others must be corrected accordingly. On the other hand, if it is impossible to find a number of stations at which the apparent local attractions agree, then it is impossible to determine the true bearings with the needle alone. What then?

If the true direction of the initial line has not been determined by plumbing the shaft, and if the apparent local attraction does not agree at a proportionally large number of stations, then observe the back-sights and fore-sights as described above, and correct the bearings with reference to the initial line as explained in Table III. Of course this method does not certainly determine the true bearings, but it finds correctly the relative directions of the several lines, and all the computations and plats will be perfectly correct, except that they will be turned around an amount equal to the difference between the assumed and the true bearing of the initial line. If the survey is made to determine the position of the various parts of the mine relative to the land lines above, then in many cases, particularly in the coal mines of Illinois, this method would give fairly good results, since the error would probably be slight, while the value of the vein would be nearly uniform. Farther, if at any subsequent time, the true direction of the initial line should be determined, then the correct bearings of all the lines of the underground survey could be determined at once by applying, as a "correction," the difference between the true and assumed direction of the first line.

Finally, it may happen that the apparent local attractions as found by the trial balance, Table III, preponderate in one direction. For ex-

ample, in Table III it will be noticed that all the corrections are "forward" except that at A. As a general rule local attraction is as likely to be in one direction as another, and hence, *unless the local conditions furnish some good reason to the contrary,* the corrections found by the trial balance should be about as much in one direction as the other,—*i. e.,* the sum of the "forward" corrections should be nearly equal to the sum of the "backward" corrections. This is not so in Table III, which is an actual survey. The local conditions gave no indications that the local attraction was more in one direction than another, and hence it is reasonable to believe that the corrections all being one way in the table was due to the fact that the true correction at A is backward an amount about equal to the average of the other corrections at the other stations, *i. e.,* about 18 min. If this correction were applied to the original bearings as in Table III, the resulting directions would be nearly the true ones. But if the correction at any station is considerably larger than any of the others, it is evident that the local attraction at this station is considerably more than the average, and hence this method of correcting the bearings should not be employed, at least the excessive correction should not be included in finding the average. If I understand it, the method of the preceding paper is essentially the same in principle as the one just described, although the two differ in the details of the method of arriving at the final results. Neither method should be employed when there is any reason for believing that the local attraction is more in one direction than another, or more at one station than another.

In the second part of this paper will be considered a modification of the preceding methods, which, under certain conditions, may be of great importance in making mine surveys.

LAND SURVEYS.

Land surveys differ from mine surveys in that the former close, *i. e.,* return to the point of beginning, while the latter, as a rule, do not. When the survey closes, the above method of observing and correcting the bearings possesses, in addition to the finding the true bearings as explained above, two important advantages, viz.: First, under every condition it affords the means of checking the accuracy of the bearings; second, it enables the true area to be determined, even if the true bearing of the sides can not be found. There are then two cases, I, when only the area is wanted; II, when the area and also the true bearings are required.

Case I.—*When only the area is wanted.*

The angles are read as described in Part one of this paper, the results being as in Table V.

TABLE V.

STATION.	BACK-SIGHT.	FORE-SIGHT.	CORRECTION.
Z	S 21° 00′ W	N 6° 55′ W	0
Y	N $\overset{6}{7}$° $\overset{55}{05}$′ W	N $\overset{55}{55}$° $\overset{25}{35}$′ W	10′ F
X	N $\overset{55}{55}$° $\overset{25}{35}$′ W	S $\overset{36}{36}$° $\overset{30}{20}$′ W	10′ F
W	S $\overset{36}{36}$° $\overset{30}{50}$′ W	S $\overset{2}{2}$° $\overset{20}{00}$′ E	20′ B
U	S $\overset{2}{2}$° $\overset{20}{40}$′ E	S $\overset{43}{43}$° $\overset{00}{20}$′ E	20′ F
T	S $\overset{43}{43}$° $\overset{00}{05}$′ E	S $\overset{69}{69}$° $\overset{25}{30}$′ E	5′ F
S	S $\overset{69}{69}$° $\overset{25}{30}$′ E	N $\overset{21}{21}$° $\overset{5}{00}$′ E	5′ F

Since the assumption is that only the area is required, it is immaterial where we commence to correct the angles; therefore we may assume the bearings taken at any station, say Z, are correct. Hence the correction at Z may be taken as zero. Beginning, then, at Z, we may correct the bearings by the method already explained. It is immaterial whether the angles are corrected in the order in which they were surveyed, or the opposite.

It will be noticed in the example cited that the back-sight at Z differs from the fore-sight at S.

If the angles had been correctly read these two should have agreed exactly. The agreement of the last corrected fore-sight with the first corrected back-sight is a valuable check on the accuracy of the work. This difference should not exceed 5 min. or 10 min. [The example cited is an actual survey made by one of the writer's students.]

CASE II.—*When the area and also the true bearings are required.*

The case requires either one of two things: First, that several successive back-sights shall agree with their corresponding fore-sights before either have been connected; or, second, that there shall be a true meridian which can be connected with a corner of the field by lines whose bearings are to be found in the same manner as are those of the boundary lines.

In the first instance, it may safely be assumed that, since a number of the fore-sights and back sights agree, the observed bearings are the true ones. Having some of the correct bearings, if there are any stations at which the back-sights do not agree with the corresponding fore-sights, they may be corrected as in Case I. If the declination is not set off on the compass it may be applied as a correction to those stations at which the back and fore-sights corresponded as above, and the correction carried on to those stations at which a difference was found.

TABLE VI.

STATIONS.	BACK-SIGHTS.	FORE-SIGHTS.	CORRECTIONS.
Z		73 10 N 69° 20′ E	3° 50′ F
Q	73 10 N 69° 15′ E		3° 55′ F
Q	14 40 N 10° 45′ E	93 40 S 89° 45′ W	3° 55′ F
T	93 40 S 89° 35′ W	43 5 S 39° 00′ W	4° 05′ F
U	43 05 S 39° 10′ W	14 35 N 10° 40′ E	3° 55′ F

In the second instance, the true bearings of the several lines can be found in succession, beginning at the meridian. The following example,—Table VI,—will illustrate this case. Z is not a corner of the field, but a point on a known meridian, the line Z Q being run to determine the declination at Q, a corner of the field. All the remaining stations are corners of the field.

Notice that the first two lines of the above record are preliminary to the survey of the field, and are required only to find the declination or correction at Q. Having found the correction at Q, the bearings are corrected as in the previous case. The back-sight from Q to U differs 5 min. from the fore-sight from U to Q, which shows that there was an error or inaccuracy of 5 min. in reading the angles.

Undoubtedly the method of connecting with a meridian is more exact than the previous one, although the latter is more convenient and shorter, and is the one which will generally be used in practice. However, if the bearings show local attraction at a number of stations, the first method of Case II can not be applied, while the second will give strictly correct results whatever the number of stations at which local attraction exists, for this is a check against possible local deflection of the needle, and also against errors in reading.

Finally, notice, first, that when the survey closes the method explained above absolutely eliminates all local attraction, and, second, that this method is frequently applicable in mine surveying.

HOW TO ESTABLISH A TRUE MERIDIAN.

D. H. DAVISON, of Minonk.

A meridian line may be determined by erecting an object on a horizontal plane; from a point at the top of the object drop a plumb line. Any time before noon mark a point indicated by shadow from the top of the object. With a radius having its center under the plumb line draw an arc through the shadow mark, and extend the arc to a point where the shadow of the object will reach it in the after part of the day. Observe the shadow when it reaches the arc and mark the place. A line connecting the two marks will be east and west. Bisect this line, and from its center draw a line to the point under the plumb line, and we have a north and south line. Greater accuracy may be attained by taking several observations of the shadow in the forenoon, and drawing as many concentric arcs, and observing when the shadow reaches them in the afternoon.

On account of the changing declination of the sun, this method will not give true results except about the 21st days of June and December, when the sun's declination is nearly stationary.

A more practical way of establishing a true meridian is by observing two circumpolar stars when in the same vertical line on or near the true meridian. The two most favorable stars at the present time to be observed by this method are Mizar and Ruchbah, when they are in vertical line with Polaris. Mizar may be considered the middle star in the handle of the Great Dipper, being the second star from the bowl of the Dipper, (Alioth being the first) and is also the second star from the end of the handle. It is a star of the third magnitude, and may be known by its having a small companion near it of the fifth magnitude. It is quite regular in its apparent motion, as it does not change in Right Ascension during the year to exceed about three and a half seconds.

Ruchbah is a star of the third magnitude, being on the opposite side of the pole in the back part of the seat of the Chair of Cassiopeia, and is also the third, or bottom, star in the back of the Chair. It is somewhat irregular in its apparent motion, changing in Right Ascension during the year nearly six and a half seconds.

Polaris is only about 1 deg. 18 min. from the pole, and on account of its nearness to the pole, and the effects of nutation, it is quite irregular in its apparent motion, changing in Right Ascension from January 1

to April 4, 1 min. 5.62 sec., on account of its apparent accelerated motion during this period. It then has an apparent retrograde motion from April 4 to October 18, of 2 min. 1.76 sec., in Right Ascension; from this latter date to the end of the year it has an apparent accelerated motion in Right Ascension of 40.88 sec., making a retrograde change in Right Ascension during the year of 15.26 sec. This apparent yearly retrograde change is increasing. It will amount to 17.77 sec. during the year 1891, and to 19.26 sec. during the year 1892, and within about six or seven years this apparent retrograde motion of Polaris will cause its apparent right ascension to increase to the amount of thirty seconds during a year.

The two stars Mizar and Ruchbah have been slowly advancing on Polaris for unknown ages, and have both caught up with him at about the same time, giving us at the present time a more favorable opportunity to establish a true meridian by this method than has ever been before, or ever will be again.

Mizar will meet Polaris on vertical line at or near the meridian when at its upper culmination for several years, and Ruchbah will pass Polaris on vertical line at or near the meridian at its lower culmination for several years. We will first consider the

MIZAR POLARIS METHOD.

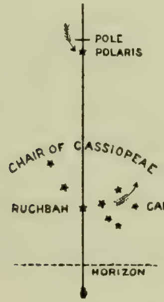
Mizar first overtakes Polaris during the present year (1890). On the 1st day of October, 1890, Polaris passes the meridian and meets Mizar on the west side of the meridian one-tenth of a second after passing the meridian. But on the following day,—October 2,—Mizar reaches the meridian first, and meets Polaris on the east side of it about one-eighth of a second before Polaris reaches it. Mizar continues to gain on Polaris until the 18th day of October, when it meets Polaris on the east side of the meridian about two and one-fifth seconds before Polaris reaches it. After this date Polaris will gain on Mizar until the 3d day af November, when he will reach the true meridian at the same instant that Mizar reaches it. After this date Polaris will meet Mizar on the west side of the meridian until the 2d day of September, 1891, when Mizar will again meet Polaris on the true meridian. They will continue to meet on the east side of the meridian until the 2d day of December,

1891, when Polaris will again overtake Mizar and meet him on the true meridian. After this date they will meet on the west side of the meridian until the 12th day of August, 1892, when Mizar will again overtake Polaris and meet him on the meridian. After this date they meet on the east side of the meridian until the 24th day of December, 1892, when Polaris will again overtake Mizar and meet him on the meridian, meeting on the west side of meridian until July 23, 1893, when Mizar will again meet Polaris on the meridian; after this, meeting to the east of it until January 13, 1894, when they again meet on the meridian. Polaris and Mizar can be observed when on the meridian at each of the preceding dates, and the true meridian can be determined by a single observation. They will meet on the vertical plane, very near the true meridian, for several days before and after the given dates.

At the following dates they will also pass and repass on the meridian, but as the phenomena occurs in the day-time they can not be observed, viz.: July 2, 1894; February 4 and June 9, 1895; also March 3 and May 10, 1896.

After the latter date the stars will never again meet in vertical line on the true meridian, but will always meet east of it. The vertical line is moving east at the rate or 6.9 sec. per year.

RUCHBAH POLARIS METHOD.



Ruchbah first overtook Polaris and passed him on the meridian September 18, 1886, and up to the end of the present year (1890) they will have passed and repassed each other on the true meridian nine times, only two of them occurring at such times as could be observed. The next time they pass on the meridian when an observation can be taken is January 12, 1891; then they pass east of it until July 4, 1891; then pass west until January 26, 1892; then pass east until June 19, 1892. The last three dates can not be observed, but observations can be taken at the four following dates:

February 15, 1893, they pass on the meridian; then pass east of it until May 27, 1893; then west of it until March 20, 1894; then pass east of it until April 23, 1894, when they pass on the true meridian for the last time, and will always pass west of it after this date.

The vertical line is moving west at the rate of 6.2 secs. per year. Observations taken at the above dates will give true results for any part of the United States or in Canada. Observations can be taken by the usual method of dropping a plumb line and watching the stars until they both come to the same vertical line; or they can be taken by using the transit.

METHOD BY ELONGATION

Perhaps the most simple and practical method of determining a true meridian is by taking an observation on a circumpolar star when at its greatest eastern or western elongation. By knowing the declination of the star and latitude of the place, its azimuth is easily determined from the simple formula

$$\text{Sin Az.} = \frac{\text{Cos Dec.}}{\text{Cos Lat.}}$$

Azimuth of Polaris for Lat. 40 deg. 53 min., on January 1, 1890, is 1 deg., 41 min., 8.8 sec., and is decreasing at the rate of 27 sec. per year.

A true meridian can be determined from any circumpolar star without finding its azimuth, as follows: Take an observation at greatest eastern elongation, and set a pin one hundred feet distant; at some subsequent time take another observation at greatest western elongation, and set a pin one hundred feet distant; bisect the line between the two pins and we have a true meridian. If our observation is taken on Polaris the pins will be very nearly six feet apart.

Perhaps the most satisfactory method of accurately determining a true meridian in a northern latitude is by taking an observation on Polaris when at its greatest eastern or western elongation.

We shonld not trust any of the tables giving the azimuth of Polaris for different latitudes, from the fact that its right ascension and declination is constantly changing during the year, this change being sufficient to cause an error in our work. In the American Ephemeris and Nautical Almanac the right ascension and declination of Polaris is given for every day in the year.

We should take the declination of Polaris from the Almanac for the day of observation, and, by knowing our latitude, the azimuth is easily determined from the formula previously given.

Although the azimuth of Polaris is decreasing at the rate of about 27 sec. per year, yet, from the 1st of January to the 26th of June it increases 40 sec., and from June to the last of December it decreases 1 min. 7 sec. Hence the necessity of determining azimuth for the time and place of observation is apparent.

The time when Polaris is at its greatest western elongation can be determined simply by observation. It occurs when the Great Dipper is to the right of Polaris, and somewhat higher, and the Chair of Cassiopeia is to the left of Polaris, and a little lower. Observe the bright star Er Rai between Polaris and Caph, the large bright star in the bottom of the Chair of Cassiopeia. Drop a plumb line, and watch when the large

bright star Alderamin comes directly under Er Rai. At the time these two stars are in vertical line Polaris is at its greatest western elongation. (Alderamin may be known by its forming an equilateral triangle with Caph and Er Rai.)

Having previously put the transit in position, and driven a nail in a stake directly under it, carefully adjust the sight line to Polaris when at its elongation. At any convenient time after turn down the telescope, and set a pin in azimuth line just one hundred feet from nail under the telescope. The true meridian can now be determined by turning off the azimuth angle by the vernier. Or it may be *more accurately* determined by measuring the tangent of the azimuth angle easterly from the pin set on the azimuth line one hundred feet from the instrument. The pin set at the end of the tangent line will be due north from the transit.

WHEN PHENOMENA OF POLARIS ARE VISIBLE.

Due North at Upper Culmination between July 26 and January 23.
Due North at Lower Culmination between December 18 and June 16.
Eastern Elongation between April 20 and October 20.
Western Elongation between October 7 and April 2.

After establishing a true meridian we have the means of determining exact true mean time by estimating the time any fixed star or planet is due south or due north, and observing it at that time, the best time for observation being in the twilight, when the spider lines and the star can be plainly seen.

Some of the stars can be seen any fair day with a surveyor's transit: for instance, Venus and Jupiter. I have also observed the fixed star Sirius on the meridian when it was within fifteen minutes of the sun.

And now, with all due respect for the opinions of those who opposed a proposition we made a year ago, I am going to repeat it: Every practical surveyor should establish a true meridian line. We should set our verniers to correspond with it, and constantly keep them adjusted to it, and make all of our surveys correspond with it, and thus avoid the everlasting uncertainty attendant on changing the variation on every survey that is made, thus making constant confusion and a most prolific cause of litigation.

Almighty God, the Great Jehovah, has given us a true and everlasting standard, and it is not only our privilege, but our duty, to follow that standard as nearly as we can.

SHARP CURVES.

EDWIN A. HILL, of Cincinnati, O.

In conversation, recently, with an engineer of maintenance of way, upon the subject of curvature, he remarked, that while it might be practical enough to use a certain curve in yard work, yet if he recommended its use, no matter under what circumstances, he should expect his head to fall at once into the official basket.

It is undoubtedly true that certain well founded objections to the unnecessary use of curves, more particularly sharp ones, on main line track, have led to an undue prejudice against their use generally,—a prejudice which often blindly disregards the exigencies of special cases, and loses sight of what are the real limitations to their use. And particularly is this the case with yard work, and around large towns and cities.

Engineers, it is true, understand these subjects better, and are less liable to hold extreme views, than the superintendents and managers, who usually control their actions; yet, even for engineers, a little discussion on this subject will not, I think, be devoid of interest, especially when we consider that an ill-founded objection to the use of a certain curve in a crowded yard, or to reach a given warehouse, may mean either an expensive purchase of land for the accommodation of curves of larger radii, or else the surrender of business which the management would be very glad to control, but are reluctantly compelled to relinquish because they can not afford the purchase, while, did they but know it, a curve somewhat sharper than their supposed limit curve could be safely operated, and be made to save the unnecessary expenditure.

This subject, so far as main line curves are concerned, has been so thoroughly treated by Mr. A. M. Wellington, in his treatise on Railway Location, that I shall confine my paper to Yard Work, seeking rather to present data from actual practice than to go too deeply into the theory and mathematics of the case, for, as the curve sharpens, we turn more and more from theory to actual practice. In mathematical language, our reliance upon theory varies *inversely,* while our reliance upon the actual experience of ourselves and others varies *directly,* as the degree of curve.

In theory, any single, four-wheeled car whose rigid wheel base is no longer than that of an ordinary street car, should turn the same curves that it will, i. e., curves of from thirty to fifty feet radius, and as the

street Station of the Little Miami Railway is almost directly under the C. and O. bridge, and here the radius of the sharpest curve was once measured carefully by an engineer of my acquaintance, and found to be eighty-four and six-tenths feet, while the Pan Handle authorities told him at the time that it was originally laid out as a ninety-two foot radius curve. About ninety degrees of central angle are here turned, though the curve is not equally sharp at all points. I have often seen trains of several cars pulled and pushed over these curves by a four-wheeled switching engine with about six feet of wheel base, and never noticed any serious difficulty from interference of ends of cars or of cars getting off track, though I have been told by others that these troubles are not uncommon. I have noticed, however, that cars not provided with dead blocks have a tendency *here* to come together at the ends, which tendancy the dead blocks entirely prevent. A conversation with one of the switchmen brought out the facts that most cars passed the curves all right, and that cars of certain types only, more particularly those with outside sills, were the most troublesome, and that the damage to corners of cars was confined mostly to occasional splintering of the ends of car sills, and to knocking off the ends of cornices, etc. I should however, have no hesitancy myself in employing curves of one hundred feet radius in yard work, to be operated by four-wheel switching engines, and also curves of sixty and fifty feet radius, to be operated by switch rope or horses, provided the exigencies of the case strongly demanded them; not that they are advisable, but rather that they can be tolerated if absolutely necessary, for of two evils always choose the least. But curves of these short radii should be put in with exceeding great care, with pains to make the elevation and curvature regular, and the necessary amount of gauge widening, and the proper setting of guard rails should be carefully worked out according to the demands of the rolling stock likely to be used thereon.

($R = 90'$).

The sharp curves of the New York elevated railroads are often referred to as practical illustrations of what can be done in this line, their radii varying from ninety feet to one hundred and fifty feet; but in that case, as the rolling stock is of special construction, the results there attained are not so applicable to practice in general as they might seem at first. It is nevertheless true, however, as stated in the Railroad Gazette, that these roads run eight hundred or more trains, of four cars each, per day, around sixty degrees curves, radii ninety and one hundred feet, with perfect ease, and with only a moderate slackening of speed. The wheel base of the cars in this case is about five feet long, or the same as that of the average freight car.

($R = 75'$).

Engineering News (1888, page 273) is the authority for the statement that dummy engines are known to haul six or seven loaded cars, at slow speeds, around curves of seventy-five feet radius.

$(R = 68\frac{1}{2}')$.

Some years since the Little Miami Railway operated a curve near the pumping station of the Cincinnati water-works, east of the Louisville and Nashville Railroad bridge over the Ohio river, which turned a central angle of about one hundred and eighty degrees, with a radius said to have been ninety-two feet, but which another friend of mine found by actual measurement to be sixty-eight and five-tenths feet in several places. He tells me he observed the action of a long train of freight cars being pushed around this curve, and noticed that the corners were all in contact, and some of them more or less damaged and occasionally stove in in consequence, and as the curve always gave trouble when operated by a pushing engine, the practical limit of curvature for direct handling of coupled cars was in this case undoubtedly exceeded.

I happened, recently, to run across a switchman who for some years handled trains in this yard before this curve was taken up, and who remembers it well. He informed me, that, comparatively speaking, there was not so very much trouble experienced with it. Cars would interfere more or less at the corners, but the damage was rarely serious, and derailments only occasional. There was a large amount of flange friction, however, and much trouble in getting trains around the curve, so that it was their custom to make a run for it, and they usually succeeded in getting around without leaving the track.

Suppose we test this curve by our previously obtained formulæ. For example, by Formula 4 we have to avoid end contact

$$W < \frac{R\,S}{L}$$

And with the assumed values $L = 36$ feet $=$ length of car from bumper to bumper, and $R = 68$

$S = 2$ feet $=$ space between cars,

We have $$W < \frac{68 \times 2}{36} = 3'\ 3''$$

Which would require dead blocks set pretty well towards corner of car to prevent end crushing.

Again by formula 3, with $S = 2$, $R = 68$, and $W = 4$

$$L > \frac{R\,S}{W} = \frac{68 \times 2}{4} = 34 \text{ feet.}$$

So that with these dimensions any car shorter than 34 feet might make trouble on the curve.

The Little Miami Railway at this time was operating a yard at this same locality, consisting of a series of tracks leading off from a tangent in which the standard radius of curvature was ninety-two feet. This yard was operated for some time with engines having six driving wheels, the middle driver being without flanges, and the wheel base being nine feet seven inches, and, as I am informed, without having much trouble from end interference of cars, though I believe they did have some trouble from cars occasionally leaving track, which, however, to my mind, only emphasizes the necessity of keeping sharp curves in A No. 1 condition.

In any car W could rarely exceed the half width of car body, or, say, be greater than four and one-half feet, nor would L, for ordinary freight cars, be likely to exceed forty feet, which limit values we insert in Formula 2, making R = 93, and we have

$$S > \frac{W\ L}{R} = \frac{4.5 \times 40}{92} = 1.9 \text{ feet.}$$

But as S averages about two feet, and usually runs above, theory confirms the practical experience that but little trouble was had from end interference on this curve.

But to return to specific examples of sharp curves:

(R = 55′).

The Railroad Gazette article, of 1878, mentions curves of radii varying from fifty-five to one hundred and twenty-five feet as occurring on the Brooklyn, Bath and Coney Island Railway's main line, though without giving further particulars.

(R = 60′).

Cincinnati furnishes an example of a curve of sixty-foot radius, which is located on Eggleston avenue, where the Little Miami Railway has a switch running into the warehouse of the American Cotton Oil Company. A central angle of ninety degrees is here turned. My understanding is that on this curve cars are usually handled singly by switch rope or stake.

(R = 50′).

In this connection the experience of Mr. M. J. Butler, as detailed in the Railroad Gazette for 1885, page 225, is of interest:

"Some years ago," he says, "it became my duty to lay out a yard at the extensive lumber mills of the Rathbun Company, of Deseronto, Ont., and, owing to the very limited room available, the sharpest workable curvature had to be used. * * * I put in several curves of fifty feet radius, about a dozen of sixty feet radius. one of seventy-nine feet radius, one of one hundred feet radius, and one of eighty-five feet radius. We were using a Baldwin 'motor,' which readily traversed all of them. We tried to place ordinary standard cars, box and flat, between the lumber piles, but they would not pass any curve of a less radius than sixty feet. I then tried a locomotive, not of the standard type, but smaller, such as are in use on the elevated railroads in New York, but it would not pass any curve of a less radius than eighty-five feet. The gauge was widened on all these curves three-quarters of an inch. My experience with these sharp curves would go to show that for an ordinary standard type of engine 7′ 6″ rigid wheel base, with four-wheeled trucks in front, four drivers, two on each side, connected, the sharpest curve workable is one of two hundred and eight feet radius, and then the curve must be widened fully one inch."

In commenting on the above, the editor of the Gazette thinks Mr. Butler fixes the limit too high, and instances the Y of one hundred and thirty-six feet radius and the one hundred and fifty feet radius reversed curves of the Mexican railway in support of this position.

($R = 40'$).

The curves at the Center street freight depots of the New York Central and Hudson River, and New York, New Haven and Hartford railroads, in New York, are under sixty feet radius, for Center street is less than one hundred and twenty feet wide between property lines, and these curves, which turn a right angle between the property line and the down tracks, which are next to the depot, must have a radius somewhat less than the half width of the street. Cars are here handled entirely by horses. In referring to the curves, the Gazette states they are much less than sixty, and, apparently, of forty feet radius, or, at least, some of them. In such cases it is usually the practice to make the outer rail flat, so that the wheels run on their flanges on the outside of the curve.

($R = 50'$).

Reference is frequently made to the celebrated curve of fifty-foot radius put in during the war by the United States Government, at Petersburg, Va., which is described in Transactions of American Society of Civil Engineers for 1876, and is also noticed by Mr. Wellington, at page 326 of his treatise on Railway Location, in the following language:

"Contrary to the advice of trackmen and bridge builders, a sharp curve was laid out, of more than one hundred degrees, with a radius of fifty feet, on what was to become the main line. The curve was on trestle work, and the outside posts were framed eight inches longer than the inner ones. The ties were of sound white pine, three inches in thickness, and the rails were double spiked. Two guard rails were also used double spiked.

"The locomotive engineers generally condemned the bridge and curve at first sight after completion, and a strong prejudice was created against it, but the writer selected the worst curve-following engine in the service, the 'Government,' and ordered her to make the first trial. Walking backwards and in front, as this engine slowly made its way, it was easy to perceive her action on this sharp curve. A little pressure on the outer rail seemed to drive the wheels,—both of the truck and drivers,—down onto the inner rail, and demonstrated practically what had been intended,—that the trains must be passed through the curve at greater speed. Thereafter, when the locomotive men became acquainted with the curve, the speed through it was usually from eight to ten miles an hour.

"A very large traffic passed over this curve for months afterwards, supplying the armies of occupation at Richmond, and at other points southward, and no accident or trouble whatever was experienced at the place in question."

To be strictly logical, a paper on this topic should begin with an enumeration of the various contingencies which establish a minimum value for the radius of curvature, which should then be discussed in proper order; but I have thought it preferable to commence with a discussion of one, only, of these contingencies, to-wit., the interference of

the corners of cars, following with an enumeration of such practical examples of curvature as I thought it would be interesting and profitable to lay before you.

The type of engine, however, which is to be used on the curve also fixed a minimum value for the radius, but a discussion of this phase of the subject is so involved with the practical questions of the necessary widening of the gauge, and the true functions and proper adjustment of the guard rails, that it is better to include them all in one more or less connected discussion, which will now be taken up.

Nearly all of the mathematics of this branch of the subiect can be reduced practically to a few simple formulæ involving the principles of ordinates from chords of circular curves, and the following fundamental formulæ, though approximate, are suggested as simple, useful, and substantially correct, with a margin of error far within the practical requirements of the case.

The first formula is for finding the middle ordinate, and is an old rule, but one which I have put in a new, and, I think, quite convenient, form; nor do I remember to have ever seen it so stated, although, as there is so little new under the sun, I am somewhat timid about claiming it as new. It is this: *"Three times the chord multiplied by half the chord, and divided by the radius, all taken in feet, gives the middle ordinate in inches."*

The other two formulæ have been published in railroad and engineering journals, and are well known to the profession.

In these formulæ

M = the Middle Ordinate.
O = Any Other.
C = The Chord.
R = Radius of Curve.
D = Degree of Curve.
n = Number of one hundred-foot stations included in the given arc.
p and p′ = Parts into which the Ordinate divides the Chord.

1st. Then with M taken in *inches* and all other dimensions in feet,

$$(9)\quad M = (3\,C \times \tfrac{C}{2}) \div R$$

$$(10)\quad R = (3\,C \times \tfrac{C}{2}) \div M$$

$$(11)\quad C = \sqrt{\frac{2\,M\,R}{3}}$$

2d. With all dimensions taken in feet or inches.

$$(12)\quad O = \frac{p'\ p''}{2\,R}$$

$$(13)\quad R = \frac{p' \times p''}{2\,O}$$

$$(14)\quad C = p' + p''$$

And when $p' = p''$ we have

$$(15) \quad M = \frac{p^2}{2\,R} = \frac{C^2}{8\,R}$$

$$(16) \quad R = \frac{C^2}{8\,M}$$

$$(17) \quad C = 2\sqrt{2\,R\,M}$$

3d. With all dimensions taken in feet.

$$(18) \quad M = 0.22\ n^2\ D.$$

$$(19) \quad D = \frac{M}{0.22\ n^2}$$

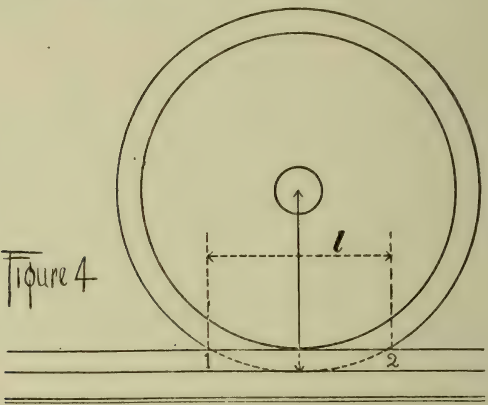


Figure 4

Lap.

In Figure 4 the two concentric circles represent the limits of the tread, and the flange of a car or driving wheel shown resting on the rail. A D being the upper surface of the rail, and the distance B C being usually termed the "lap" t is the depth of flange, which is usually one and one-eighth inches. The lap varies with the diameter of the wheel, and can be found by the formula, (approximately correct),

$$(20) \quad l = 1\ 2 = 2\sqrt{2\,r\,t} = 2\sqrt{2\,t} \times \sqrt{r} = 3\sqrt{r}$$

Where l = lap in inches

r = radius in inches

t = depth of flange assumed at $1\frac{1}{8}$ inches

Practically, the lap in any given case can be quickly ascertained by sliding two pencils along the head of rails till they make contact with the flanges, and then measuring the distance between them, which result will be a little in excess of the true lap. The lap enters as a factor into all the formulæ for the determination of gauge widening, minimum radius as fixed by wheel base, adjustment of guard rails, etc. In these formulæ, however, the lap is only required correct to the nearest inch,

and from the following table it can be taken at once by inspection, without calculation, the table being based on a flange depth of one one-eighth inches.

Flange $1\frac{1}{8}$ in. deep.	Diameter of	wheel	17 to 20 in.	Lap = 9 in's.	Correct to nearest in.
	"	"	21 " 24 "	" 10 "	" " "
	"	"	25 " 29 "	" 11 "	" " "
	"	"	30 " 34 "	" 12 "	" " "
	"	"	35 " 40 "	" 13 "	" " "
	"	"	41 " 46 "	" 14 "	" " "
	"	"	47 " 53 "	" 15 "	" " "
	"	"	54 " 60 "	" 16 "	" " "
	"	"	61 " 68 "	" 17 "	" " "
	"	"	69 " 76 "	" 18 "	" " "

The various types of running gear with which we have to deal, except in special cases, fall into three general classes, and can best be considered separately. There are:

Class I. Four-wheeled trucks, forming a rigid wheel base, the class including the ordinary freight and passenger trucks, and the driving wheel bases of four-wheeled switching engines.

Class II. Six or more wheels, set in a continuous frame, with or without a certain amount of lateral play in the axle boxes, the class including six-wheeled passenger and freight trucks, and the driving wheel bases of Moguls, consolidation and six-wheeled switching engines. In the case of the engines the middle wheels usually have blind tires, making a special subdivision of this class. In the Mogul and consolidation types the driving wheel base is preceded by a two-wheeled pony truck having a radial motion.

Class III. Engines having a rigid frame, with from four to eight driving wheels, constituting a more or less rigid wheel base, with or without lateral play in the boxes, the driving wheels preceded by a four-wheeled boge truck, pivoted to the front, with or without swing or similar motion, this class including the eight-wheel, or American, the ten-wheel, and the so-called Mastodon type of engine.

These classes are stated in the relative order of ease with which they traverse curves, though it frequently happens that a type of running gear of a higher class will traverse sharper curves than one of a lower, owing to relative differences in length of wheel base, amount of play, etc.

When the general principles applicable to the above classes and types are well understood, no trouble will be met with in the consideration of any special type of running gear not properly included in the above classes.

Class 1. Taking up in order the several classes, we begin with Class 1. Figure 5 represents the axles and the "lap" of each wheel of a four-wheeled truck, with the gauge widened so as to just clear the lap at all points by an amount equal to the ordinary clearance between the flange and the rail head.

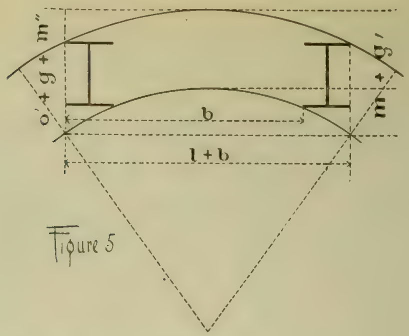


Figure 5

Let g = the true gauge.
g′ = the widened gauge = w + g.
w = the necessary amount of gauge widening = g′ — g.
l = the lap.
b = the wheel base, or distance between wheel centers.

And for chords equal to l + b,
m′ = the middle ordinate for inner rail.
m″ = the middle ordinate for outer rail.
o′ = the ordinate at lap distance for inner rail.

Then, evidently,

$$m' + g' = o' + g + m'' \text{ and}$$
$$w = (g' - g) = o' + (m'' - m')$$

But for all probable values of the radius the value of m″ so closely approximates that of m′ that we can discard the quantity (m″—m′) without practical error and unite the equation

$$(21) \quad W = o' = \frac{l \times b}{2\,R}$$

the latter form being derived from the formula for an ordinate at any point of the chord, o being taken at a distance "l" from the end of the chord l + b.

The question here arises to what extent is it safe to widen the guage, for whenever a given type of truck on wheel base calls for an unsafe or impractical widening, then a minimum radius of curvature is thereby established for that particular type. As to what this limit should be will depend on the width of the wheel tread. In 1886, the editor of the Railroad Gazette, (p. 293) remarked, "That two inches (of widening) is ever expedient, we do not believe." Mr. Cleeman says *we should never widen more than 1 1-2 inches with wheels of ordinary tread.* We may assume the average tread to be about 4¼ inches wide and allowing ¾ inch play for the wheels and a width of rail head of 2¼ inches we shall have, with a guage widened 1½ inches and with the flange in contact with the outer rail, a bearing of about 2 inches on the under rail and with wheels with flanges so worn as to increase the lateral play to 1¼ inches, the bearing will be reduced to about 1½ inches, and any further reduction of this bearing by widening above 1½

inches would seem to be of doubtful propriety. Taking an extreme case by way of illustration; assume a wheel base of four, 6 foot driving wheels $8\frac{1}{2}$ feet between centres and we have

$$l = \text{lap} = \text{(by table) } 17''.$$
$$b = 8'\ 6'' = 102''.$$
$$R = 40' = 480''.$$

$$W = \frac{l \times b}{2\ R} = \frac{17 \times 102}{2 \times 40 \times 12} = 1.4''$$ which is within one limit of $1.5''$

So that running gear of Class I, can pass almost any curve whatever, and here we see one reason for the adoption of the 4 wheeled switching type of engine for yard service, combining as it does, this facility for turning curves without binding combined with its concentration of the entire weight upon the drivers.

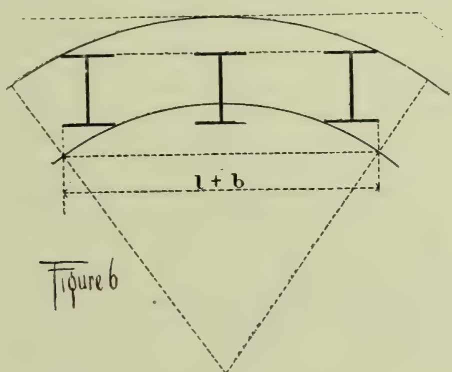


Figure 6

Class II. (See Fig. 6.)

Trucks having 6 flanged wheels without any lateral play in the axles being equally spaced, require a widening of the guage found by the following formula:

$$(22)\quad W' = \frac{(b \times l)^2}{8\ R}$$ and must be less than $1\frac{1}{2}''$

That is to say W' is the middle ordinate for a chord equal to sum of the wheel base and lap. Apply the above formula to a 6 wheel truck P. & R. parlor car, wheel base $10'$, lap $1'$, $R = 160'$ and we have

$$W' = \frac{11 \times 11}{8 \times 160} = \frac{132}{1280} =$$ about one-tenth foot $= 1.2$ inches.

Six wheeled passenger trucks are occasionally made with a certain amount of lateral play in the boxes to help them around sharp curves. and I have been informed this sometimes amounts to as much as $\frac{3}{4}$ of an inch.

Let a = lateral play,
then we must have

$$W'' = \frac{(l + b)^2}{8\ R} - a$$

Or, in other words, each $\frac{1}{4}$ inch of lateral play reduces the necessary widening of guage by that amount.

In the case of passenger trucks the central pair of wheels is usually midway between the other two, but not always. In the exceptional cases the necessary widening can be found by taking $l + b$ as the chord and computing the ordinate at the central pair of wheels, subtracting the lateral play from the result and the remainder will be the necessary widening, which, as before, must be less than $1\frac{1}{2}''$. Should it exceed this limit, the radius of curve must be increased. As an example, assume a 6 wheeled truck, all wheels flanged, axles spaced 4 and 5 ft. respectively, with $l = 1$ ft. and $R = 100$ ft., then by Formula No. 13,

$$(24)\quad W'' = o - a = \frac{4.5 \times 5.5}{2 \times 100} = .124 \text{ ft} = 1.48 \text{ inches.}$$

Computing o by formula 13, taking p' and p'' equal to distances of any axle from ends of chord, and if a be three-tenths inches, $W = 1.48 - 3 = 1.18$ ins. Where the six wheels form a driving base, we usually find one of the pairs of wheels furnished with a blind tire that is without flanges, and in this case, for a whee. without flange, the value of W'' in above equation gives the amount by which the wheel tends to move laterally off the rail. When this movement becomes so great as to carry the wheel entirely off the rail, additional support must be provided, which contingency will be considered under the topic of guard rails.

The above formula can be used for any number of wheels set in a rigid frame, whether with or without lateral play, and so applies to all cases of mogul and consolidation engines, as well as 6 wheeled passenger trucks.

Class III. differs from the others, in that the rigid wheel base is preceded by a 4 wheeled bogie truck, pivoted to the centre of the frame so as to assume the radial positions on curves. This differs from Class II., in that the two wheeled pony truck of that class swing on a pivot to rear of the axle. In the types of Class II., the rigid wheel base extends only from the rear to the forward driving wheels, but with the types of Class III., the rigid base is practically extended to a point a little forward of the centre of the bogie truck. If as is sometimes the case this truck is a "swing motion truck," the theory of extended wheel base is in no ways affected thereby for the amount of lateral play represented by "a" in the equations can be taken to include the results of this swing motion, together with the sum of the play in all the boxes.

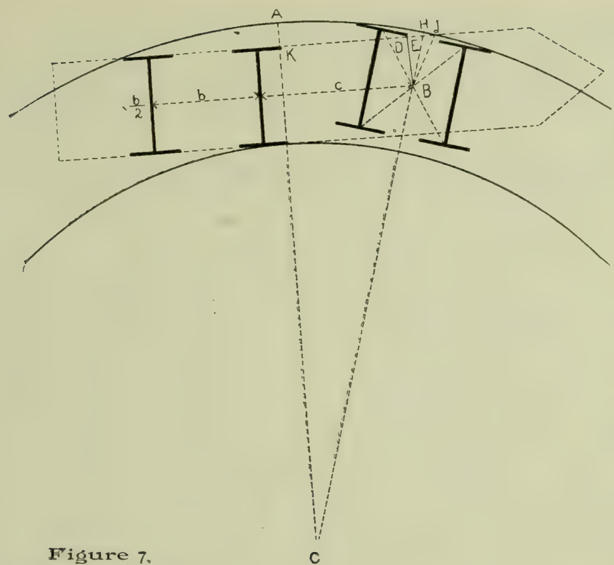


Figure 7.

Referring now to Fig. 7.

By similar triangles we have

D E : D B :: K E : K C

and since D B $= \frac{g}{2}$ and approximately, K C = R and K E $= \frac{l + b + c}{2}$

(assuming $\frac{1}{2}$ l = D E)

then D E : $\frac{g}{2}$ :: $\frac{l + b + c}{2}$: R

D E $= \frac{g\,(l + b + c)}{4\,R}$ which quantity we will call f

again E J : E H :: E B : D E

E J : E H :: $\frac{g}{2}$: D E

$$D\,E \times E\,J = \frac{g \times E\,H}{2}$$

E J $= \frac{g \times E\,H}{2\,E\,D}$ which quantity we will call f′

(25) $f = \frac{g\,(l + b + c)}{4\,R}$ and $f' = \frac{g \times E\,H}{2\,f}$

Now if b′ = wheel base and l′ lap for bogie truck in class III, putting M′ = middle ordinate, we have M′ $= \frac{(b' + l')^2}{8\,R}$ = E H

$$(26)\quad f' = \frac{g}{2f}(E\ H) = \frac{g}{2f}\frac{(b' + l')^2}{8\ R}$$

From these two formulas may be computed, the value of D J near enough for all practical purposes, its only use being to determine the chord J M.

And putting C = distance from forward driving axle to centre of bogie truck we have

$$(27)\quad \text{Chord J M} = (\frac{1}{2} + b + c + f + f')$$

All questions concerning the necessary widening of guage and extra support for the drivers having blind tires are to be worked out on the principles of ordinates taken at various points on the above chord.

The figure shows the tendency of the bogie truck to hug the outer rail and the guage widening as before should not exceed 1½ inches. The usual practice now is, to make the forward driving wheels with blind tires, though the rule is not universal. Generally the ordinate taken at the blind tire axle determines the guard rail question. And the ordinate taken from the end of the lap which comes nearest the centre of the chord (after all of the lateral play has been deducted) determines how much the guage must be widened, which, as before, must always be less than 1½ inches, and should this limit be exceeded, then the radius of curve must be increased till this condition is complied with.

I have endeavored to obtain some idea of the amount of lateral play in engines as it averages on various roads, but have not been able to get as much data on this point as I could desire.

One of the road masters of the Denver & Rio Grande Road stated, in 1886, (Railroad Gazette, p. 293) that at that time the lateral play of axles, boxes and all bearings in their engines amounted to about 2½ inches, that is, while the flanged wheels at both ends are held firmly to one side, those in or near the middle may be forced that distance in the opposite direction.

It is quite probable, as the editor remarked in his comments on same page, that the greater part of this so called "lateral play," came from some swing on similar motion in the bogie truck.

On the C. N. O. & T. P. Ry., with engines having no swing motion on the bogie truck, I am informed, they consider an engine should be overhauled when the total lateral motion in all boxes amounts to ¾ of an inch, and in ordinary calculations I should hesitate about assigning to the quantity "a" a larger value than ½ inch, unless there was a swing or some similar motion in the bogie truck.

We here see a reason for the well known fact that engines fresh from the shop are the most apt to make trouble on curves. The "boys" say they are new and "stiff" and they are not far out of the way either. Until the boxes wear a little, the value of "a" is so small that their capacity for turning curves is thereby just so much reduced.

For a test case let us take a Baldwin 10 wheeler, Class 10-32-W of the Baldwin Catalogue, coming under Class III., of this paper. 54″ drivers 6 in all, with the two leading drivers having blind tires preceded by the usual bogie truck without swing motion and having the following dimensions:

$$\left.\begin{array}{l}\text{Rear to central driving axle, } 8'\ 2'' \\ \text{Central to forward driving axle, } 5'\ 4''\end{array}\right\} = b = 162''$$

Forward driving axle to central bogie truck 8′ o″ = C = 96″

$\frac{1}{2}$ lap for 54″ wheel (by table) 8″ $= \frac{1}{2}$

Wheel base of bogie truck 5′ 9″ = b′ = 69″

Then chord $= (\frac{g}{2} + b + c + f + f') = 8'' + 162'' + 96' + f + f'$

But by formulas Nos. 25 and 26

$$f = \frac{g\ (l + b + c)}{4\ R} \quad \text{and} \quad f' = \frac{g\ (b' + l')^2}{16\ f\ R}$$

Where $l' + b' = 5'\ 9''$.

Assume a 24 degree curve, Radius = 240 ft. with $g = 4'\ 9'' = 57''$, hence $f = 1.4''$ and $f' = .4''$, $f + f' = 2''$ nearly, chord $= (8'' + 162'' + 96' + 2'') = 271''$.

For guage widening, take ordinate at distance from left hand (assuming engine headed to the right) equal to

$\frac{1}{2} + 8' - 2'' + \frac{1}{2} = 98'' + 16'' = 114''$

The parts of chord are therefore 114 and 154 inches. Hence by Formula No. 23,

$$W'' + a = \frac{114 \times 154}{2 \times 240 \times 12} = 3''$$

So that we should require a lateral of at least $1\frac{1}{2}$ inches, or else a widening of guage of more than the safe limit of $1\frac{1}{2}$ inches.

The question of how the guard rails should be placed, will now be taken up. Taking the wheel base as the chord of an arc, it will often be found that the ordinate at one of the central driving wheels will be so large as to carry the tire clear off the rail, which necessitates supporting the driver by a second or guard rail, and this is the reason why in a system of driving wheels certain of them are usually made with blind tires, for without them the flanges by coming in contact with the rails would render it impossible for the engine to pass the curve.

The proper setting of the guard rail on a sharp curve, is an important matter. From $1\frac{3}{4}$ to 2 inches, is the usual clearance allowed between the guard and stock rails on tangents, but as the radius of curvature decreases, this distance must be increased. As before we should form a chord in the same manner as was presented for the computation of the guage widening (i. e. adding lap to wheel base in Class II., and in Class III., adding to the half lap the distance from hind driving axle to pin of bogie truck, and also adding the two quantities, f and f′), and then by the formulas for ordinates we should compute

the ordinates for each set of blind tires. Should these ordinates in any case indicate an insufficient bearing for the blind tire, then additional guard rails should be placed to afford it additional support and they should be placed on the inside of the outer rail and on the outside of the inner rail. If the distance between centres of guard and stock rail is just equal to the width of the blind tire, the bearing will pass muster, though it would be preferable to crowd the guard rail up closer to the stock rail, provided this did not necessitate the use of an additional guard rail. The minimum distance between stock and guard rail may be taken at $1\frac{3}{4}$ inches, and the width of rail head at about $2\frac{1}{4}$ inches and evidently the maximum space between the guard and stock rail will be the width of blind tire, less $2\frac{1}{4}$ inches. And if we average the blind tire widths at 6 inches, this distance will be $3\frac{3}{4}$ inches as a maximum, or in form of an equation.

Put U = width of blind tire.
V = " of rail head.
S = clear space between stock and guard rails.

(28) Then S *must* be less than (U — V).

But further so long as the tire has a full bearing on both rails no possible objection can be made to an increase of S so we have

(29) S should, if possible, be less than (U — 2 V).

But it is evident that for inner guard rails the space S must be large enough to pass the lap of all flanged wheels, hence we have a minimum value of S fixed by this latter consideration.

Let X = this value being the additional space required to pass the flanged wheels on curves.

Then we must have

(30) S greater that $X + 1\frac{3}{4}$ ins.

(N. B. where wheels of both $4'\ 8\frac{1}{2}''$ and $4'\ 9''$ guage are in use take $S > X + 2$ ins.)

To compute X we use the same chord as was used to compute the value of W or the guage widening, which chord varies in value in the three classes of running gear.

In Classes I. and II., it is $l + b$, in Class III., however, it is equal to $(\frac{1}{2} b + c + f + f')$ as already explained. Having determined our chord, we inspect the wheel base diagram and selecting that end of one of the laps which is nearest the centre of the chord, we compute the ordinate by any of the ordinate formulas (Nos. 9 to 15) and the result is the value of X.

The three guard rails usually put down on a very sharp curve, I shall designate respectively as the inner guard to inner rail, outer guard to inner rail and inner guard to outer rail, the terms requiring no explanation. Each requires somewhat different treatment from the others.

1st. Inner guard to inner rail. This performs the functions of a true guard rail and never affords any support to the blind tires, and it should be so spaced that we have

$$S > X + 1\tfrac{3}{4} \text{ ins.}$$

Since $1\frac{3}{4}$ inches is the maximum space allowed on tangents.

2d. Inner guard to outer rail. This is a guard rail in name only, its true function being to afford support to the blind tire when by sharp curvatue it is carried off the stock rail, and we must have it so spaced that as before

$$S > X + 1\tfrac{3}{4} \text{ ins.}$$

In order that all running gear may pass, and

$$S < (U - V) \text{ and preferably}$$
$$S < (U - 2\ V),$$

in order to ensure a perfect bearing for the blind tire. We should also be careful that the ordinate at the axle of blind tire is not so great as to carry the tire laterally so far as to reduce the bearing on guard rail below what is advisable, in which case additional support should be provided, either by spiking down an additional rail, or else by spiking a hard wood 4 inch plank close up to guard rail.

3d. Outer guard to inner rail. This also is a guard rail in name only, and performs the same functions as the rail just mentioned, but is subject only to the limitation

$$S < U - V \text{ and preferably}$$
$$S < U - 2\ V,$$

for evidently the limitation $S > X + 1\frac{3}{4}$ ins. does not apply, as the flanges never enter the space S. Ordinarily this rail should be spiked as close as possible, but as the curve sharpens and the value of the ordinate at the axle of the blind tire increases, there comes a time when, unless we increase the value of S, the blind tire will be carried so far off as to reduce the bearing on the guard rail, below what is advisable. To obviate the necessity of providing extra support, S may be increased until

$$S < U - 2\ V,$$

and in extreme cases, possibly until

$$S < U - V,$$

but probably the better way would be to assign to U its minimum probable value, and then having made $S = U - 2\ V$. to provide any additional support required by spiking 4 inch hard wood plank against the inner edge of the guard rail.

As an illustration of what can be done in special cases, I will describe a curve which I put in at Decatur, Ill., some two years since, while connected with the I. D. and S. Ry, the object being to reach the loading platform of the Aultman & Taylor warehouse. Starting from a four degree curve, I first laid about 130 feet of a 20° 24′ curve, then about 25 feet of 50 foot radius turning a central angle of 34° 17′ followed by about 25 feet more of 100 foot radius curve turning 17 degrees of central angle, the total angle turned in 50 feet being about 52 degrees. The curves of both track and loading platform, the latter being the last constructed, were defined by driving nails in stakes set at the true centre of curve, and with a steel tape hooked over the nail, an actual arc was swung and the curves traced on the ground and verified

during construction. Rails were bent by a jim crow by the method of ordinates. In practice the engine handles but one car, coupling head on, and its driving wheels are never supposed to leave the 20 degree curve. In this case the wise ones of the transportation department confidently asserted that no car could ever get around "such a thing as that." The car disappointed them, however, so they relieved their minds by christening it the "ram's horn curve," which name for aught I know still attaches to it.

Before closing, I wish to call attention to a few facts in a general way, noting briefly their bearing on the questions I have already discussed.

Lost motion or lateral play in engines, which is the consequence of wear in axle boxes, looseness of centre pins on king bolts of trucks and similar causes often enables them to get around curves, which it would be otherwise impossible for them to traverse. Undoubtedly during the civil war, the government engines were kept in service until this lost motion was a very considerable quantity; and how far this throws light on the operation of the celebrated 50 foot radius curve at Petersburg, Va., is an open question. Generally this play is at its minimum when an engine is just out of the shop, such engines being notoriously stiff and troublesome on curves of sharp degree.

With the horizontal hook type of coupling used with passenger cars, and now gradually coming into use for freight cars, two things should be remarked, first the liability of certain types to become uncoupled on sharp curves, which usually happens with passenger equipment and certain types of couplers, and second, that the use of these couplers with freight equipment tends generally to an increase of the quantity "S" and so to facilitate the passage of sharp curves.

The effect of outside end sills is generally adverse to the passage of sharp curves, as usually the pair of cast iron dead blocks which are almost invariably found with this type of car are placed so near the draw bar that the ratio of S and W is reduced below the average, and such cars give more trouble on sharp curves than those of the other types. Generally speaking, the further the dead blocks from the draw bar the sharper the curves which the car can traverse.

The extra height of buggy and furniture cars, though of no moment on level track, becomes important when any elevation is given to the outer rail, and should be allowed for.

Frequently we find various attachments and appliances placed on the ends of box cars which, on sharp curves, may come in contact before the ends, and hence establish a limit of curvature, such as ladders, projecting bolts, corner plates, brake wheels, etc. These should all be taken account of, but obviously no general principles can be laid down, as such details vary with every type of car, though the cases where they fix the limit are the exception rather than the rule.

Ruleably the cornices at the upper corners of box cars, projecting as they do from $1\frac{1}{2}$ to 4 inches, are the first parts to come in contact; 3

inches is about the average projection, so that the effect of cornices is to reduce the quantity S by about 6 inches, the damages usually resulting from this cause are not very serious.

As a general summary of the subject of sharp curves and the limitations to their use, it would appear that curves of at least 30 degrees can be used in passenger yards, and that where coupled freight cars are to be handled by engines in freight yards, curves can be used with a radius as low as 90 or 100 feet, subject to occasional damage to cornices of cars when trains of coupled cars are pushed over the curve. And that single freight cars, however handled, can turn any curve that a street car can, i. e, up to at least 40 feet radius.

Notwithstanding all which curvature should always be made as light as possible to avoid excessive wear of rails and tires, danger of derailment from cars with sharp flanges, etc., etc., but that these objections should not for a moment be weighed against very considerable expense for land purchases to avoid sharp curvature, nor should they in a crowded city prevent access to any warehouse or manufacturing establishment which it is really desirable to reach.

In all cases of sharp curvature the main essential is accuracy in the bending of the rails. Ordinates from both long and short chords should be calculated and the rails tested at several places with the chords taken to over-lap each other. The sharper the curve the more accurately should the rails be curved. Running gear will readily pass around a track curved *uniformly* to a radius of 100 feet, which will promptly leave the track at the first kink in a curve of far greater radius, and where the case is carefully considered, the reason is not far to seek.

The golden rule as regards sharp curves is, to use the largest radius permissible, but never hesitate to use any radius really necessary to accomplish the end in view, which actual practice shows can be tolerated.

I close this paper with a series of actual measurements of freight and passenger cars, taken for the purposes of this paper, followed by a summary of the various formulas already explained. The measurements were taken at random, and in the case of freight cars show clearly that the standard car at present is the 34 foot car, 50,000 lbs. capacity. The values of W & S were measured correctly to within about an inch. In computing the value of R twice the width of cornice has been deducted from S and the stated length of box cars has been increased by S + 1.3 for obvious reasons, as the stated length is usually the inside clear space, 1.3 feet being allowed for the width of the two end partitions of the cars, the quantity S being the additional length to represent the distance from bumper to bumper. In some instances the length of cars was not stated and the length was estimated by pacing, and in these cases the fact is indicated by an asterist thus (*). For flat cars the value of S only is added to I.

DIMENSIONS OF FREIGHT CARS.

FROM ACTUAL MEASUREMENTS.

Line.	Car Number.	Class.	Capacity.	Stated Length.	Width of Cornice.	Values of W	Values of S	R. as Computed.	Degree of Curve.	Remarks.
				Ft.	In.	In.	In.	Ft.		
St. Charles Car Co.,	257	Box	50,000	40	3	59	26	125	47°	Furniture Car.
Union Pacific,	39,365	Box	40,000	38	3	52	20	152	38°	Furniture Car.
Ohio & Mississippi,	8,019	Box	40,000	36	3	57	26	104		Buggy Car.
C. I. St. L. & C.,	4,155	Box	60,000	36	2	54	28	89		
Illinois Central,	3,155	Box	40,000	35	3	51	26	98		
Col. Spfg. & Cinti	11,170	Box	50,000	34	3	54	22	125	47°	
Chesapeake & Ohio,	40,071	Box	50,000	34	3	56	26	102		Refrigerator Car.
Lake Erie & Western,	3,859	Box	50,000	34	2	56	24	101		
Louisville Southern,	1,008	Box		34	3	47	28	80		
Chesapeake & Ohio,	3,002	Box	50,000	34	3	51	20	134	44°	
" "	577	Box	60,000	34	3	53	20	140	46°	
Kentucky Central,	784	Box	50,000	34	3	54	22	122	48°	
C. C. C. and I.,	A 1,047	Box	50,000	34	3	39	20	103		Dead Blocks and
C. B. and N.,	2,770	Box	50,000	34	3	55	30	87		outside end sills.
G. R. and I.,	3,646	Box	50,000	34	3	38	20	100		2 Dead Blocks.
T. A. A. & M.,	222	Box	40,000	34	3	53	24	109		
Chesapeake & Ohio,	4,932	Box	50,000	34	3	55	30	61		Westtinghouse
T. P & W.,	692	Box	50,000	34	2	56	24	101		Coupler.
B. and O.,	36,162	Box	50,000	34	2	51	12	149	39°	
C. W. and B.,	4,903	Box	40,000	34	3	41	24	84		Outside end sills.
C. C. & I.,	A 2,661	Box	50,000	34	4	40	22	106		2 Dead Blocks, and no
C. M. & St. P.,	15,684	Box	40,000	34	3	54	28	94		end sills
C. St. P. M. & O.,	10,138	Box	40,000	34	2	55	24	102		
C. B. & N.,	1,677	Box	50,000	34	3	52	28	89		
C. H. & D.,	7,882	Box	50,000	34	3	54	20	141	42°	
L. N. A. & C.,	4,415	Flat	40,000	34	0	54	22	89		
C. W. & M.,	747	Flat	50,000	* 34	0	54	28	66		
C. I. St. L & C.,	1,264	Flat	40,000	* 34	0	52	26	68		
C. H. & D.,	8,306	Box	36,000	33	3	54	21	129	46°	
L. N. A. & C.,	8,443	Flat	40,000	33	0	55	30	67		
G. R. & I.,	205	Flat	40,000	33	0	38	12	108		2 Dead Blocks
C. V. & C.,	878	Box	40,000	32	3	55	30	82		
N. O. & N. E.,	1,524	Box	40,000	32	3	56	24	109		
C. S F. & C.,	18,800	Box	30,000	30	3	52	28	80		
Kentucky Central,	504	Box	40,000	30	3	54	28	75		Refrigerator.
P. C & St. L.,	6,878	Box	40,000	* 30	3	31	14	116		2 Blocks and outside
L. E. & W.,	1,420	Box	30,000	30	3	50	22	104		end sills.
I. B. & W.,	624	Box	30,000	* 30	3	52	22	98		
C. I. St. L. & C.,	2,552	Box	40,000	30	2	52	26	70		2 Dead Blocks and
P. F. W. & C.,	7,395	Box	40,000	* 30	2	35	16	87		outside end sills.
C. W. & B.,	5,000	Box	26,000	* 30	3	54	30	73		Outside end sills.
I. & St. L.,	255	Flat	40,000	30	0	51	24	68		
O. & M.,	3,691	Box	26,000	28	3	46	20	102		
C. M. & St. P.,	7,582	Box	30,000	28	3	50	18	128	46°	
N. Y. L. E. & W.,	26,637	Box		28	2	54	26	74		
C. Y. & C.,	13,127	Box	28,000	28	3	50	28	72		
Lehigh Valley,	3,288	Box	50,000	28	3	39	21	80		
C. M. & St. P.,	11,896	Box	30,000	28	3	50	30	66		
Wabash,	10,202	Box	40,000	28	3	48	28	52		

DIMENSIONS OF PASSENGER CARS.

FROM ACTUAL MEASUREMENTS.

Initial.	Car Number.	Class.	Value of W	Value of S	Length out to out of bumper.	R. as computed.	Degree of Curve.
			In.	In.	Ft.	Ft.	
Wagner P. C. Co.,.......	204	Sleeper.	44	12	72	264	22°
Wagner P. C. Co.,.......	273	Vestibule Sleeper.	26	8	72	234	25°
Wagner P. C. Co.,.......	98	Sleeper.	51	12	70	291	20°
C. C. C. & St. L. Ry.,....	284	Vestibule Chair Car.	26	8	60	195	30°
C. C. C. & I. Ry.,........	368	Coach.	44	10	54	237	25°
N. Y. P. & O. Ry.,.......	450	"	44	10	54	237	25°
N. Y. L. E. & W. Ry.,...	1261	"	52	9	54	336	17°
C. C. C. & I.,............	308	"	48	12	52	218	26°
C. W. & B. Ry.,.........	19	"	46	12	45	173	34°

POSTULATES.

(The quantities usually sought are marked thus *.)

C = Chord.
*D = Degree of curve.
*L = Length of car from bumper to bumper.
*M = Middle Ordinate.
*O = Any Ordinate.
*R = Radius of curve.
*S = Clear space between corners of cars when pushed on a tangent.
*W = Distance from corner of car to edge of bumper, dead block or other point of contact.
a = Lateral play or motion in all axle boxes and connections.
b = Rigid wheel base, i. e. distance between centres of axles in a series of wheels placed in a rigid frame.
b′ = Wheel base of bogie truck in Class III.
c = Distance from forward driving axle to centre of bogie truck.
*d = Lateral displacements of car corners caused by elevation of outer rail.
e = Elevation of outer rail of curve.
f and f′ = Additions to lengths of wheel base for Class III.
g = Guage.
g′ = Widened guage.
h = Heighth of car corner above rail.
*l = The lap (generally).
l′ = The lap of a bogie truck for engines of Class III.

$$\left.\begin{array}{l}\text{m}' = \text{The Middle Ordinate for inner rail.}\\ \text{m}'' = \text{" " " " outer "}\\ \text{o}' = \text{" Ordinate at lap distance for inner rail.}\end{array}\right\}\text{for chord} = (\text{b} + \text{l}).$$

n = " Number of 100 foot stations in the given chord.
p′ and p″ = Parts into which the ordinate divides the chord.
r = Radius of wheel (usually taken in inches).
*s = Clear space between stock and guard rail.

t = Depth of flange, (usually $1\frac{1}{8}$ inches).
u = Width of blind tire.
v = " " rail head.
* W = Guage widening necessary for 4 wheeled trucks, Class I.
* W′ = " " " " 6 wheeled flanged trucks equally spaced, Class II.
* W″ = Guage widening for 6 or more wheeled trucks, however spaced, in Class II.
W‴ = Guage widening for 6 or more wheeled trucks, however spaced, in Class III.
* X = Additional space required between guard and stock rails to pass wheel flanges on curves.
Chord J M = Special wheel base chord for Class III.

FORMULA C = CHORD.

No. $C = \sqrt{\frac{2\ M\ R}{3}}$ (M taken in inches, all other quantities in feet.

14. $C = p' + p''$
17. $C = \sqrt{2\ R\ M}$ } (All quantities taken in either ft. or inches.)

L = LENGTH OF CAR FROM OUT TO OUT OF BUMPERS.

3. $L < \frac{R\ S}{W}$ (To avoid end contact, disregarding elevation.)

7. $L < R\ S \div (W + \frac{h\ e}{g})$ (To avoid end contact but allowing for elevation.)

M = MIDDLE ORDINATE. O = ANY ORDINATE.

9. $M = (3\ C \times \frac{C}{2}) \div R$, (M taken in inches, all other quantities in feet.)

15. $M = \frac{C^2}{8\ R}$
18. $M = 0.22\ n^2\ D$ } (All quantities taken in inches or feet.)
13. $O = \frac{p' \times p''}{2\ R}$

R = RADIUS OF CURVE.

1. $R > \frac{W\ L}{S}$ (To avoid end contact, disregarding elevation.

5. $R > \frac{L}{S}(W + \frac{h\ e}{g})$ (To avoid end contact, but allowing for elevation.)

10. $R = 3\ C \times \frac{C}{2}) \div M$ (M taken in inches, other quantities in feet.)

13. $R = \frac{p' \times p''}{2\ o}$
16. $R = \frac{C^2}{8\ M}$ } (All dimensions taken in feet or inches.)

S = SPACE BETWEEN ENDS OF CARS WHEN PUSHED ON A TANGENT.

2. $S > \frac{W\,L}{R}$ (To avoid end contact and disregarding elevation.)

6. $S > \frac{L}{R}\left(W + \frac{he}{g}\right)$ (To avoid end contact but allowing for elevation.)

W = DISTANCE FROM CORNER OF CAR TO EDGE OF BUMPER.

4. $W < \frac{R\,S}{L}$ (To avoid end contact and disregarding elevation.)

6. $W < \frac{R\,S}{L} - \frac{h\,e}{g}$ (To avoid end contact but allowing for elevation.)

d = LATERAL DISPLACEMENT OF CAR CORNERS CAUSED BY ELEVATION.

$$d = \frac{h\,e}{g}$$

f and f′ = ADDITIONS TO WHEEL BASE FOR CLASS III.

25. $$f = \frac{g\,(l + b + c)}{4\,R}$$

26. $$f' = \frac{g\,(b' + l')^2}{16\,f\,R}$$

l = THE LAP.

20. $l = 2\sqrt{2\,r\,t} = 2\sqrt{2\,t}\sqrt{r}$ and for $t = 1\frac{1}{8}$ inches $l = 3\sqrt{r}$

s = CLEAR SPACE BETWEEN STOCK AND GUARD RAIL.

$s > x + 1\frac{3}{4}$ inches. (for inner guard to inner rail.)

$\left.\begin{array}{l} s \text{ must be } < (u - v) \\ s \text{ preferably } < (u - 2\,v) \end{array}\right\}$ (for outer guard to inner rail.)

$\left.\begin{array}{l} s > (x + 1\frac{3}{4} \text{ inches}) \\ s \text{ must be } < (u - v) \\ s \text{ preferably } < (u - 2\,v) \end{array}\right\}$ (for inner guard to outer rail.)

w, w′ w″, etc., = WIDENING NECESSARY FOR VARIOUS TRUCKS.

21. $w = \frac{l + b}{2\,R}$ and must be $< 1\frac{1}{2}$ inches for $\left\{\begin{array}{l} \text{Class I, 4 wheeled trucks.} \\ \text{Chord} = l + b. \end{array}\right.$

22. $w' = \frac{(l + b)^2}{8\,R} + a$, and must be $< 1\frac{1}{2}$ inches for $\left\{\begin{array}{l} \text{Class II, 6 wheeled trucks, wheels equally spaced.} \\ \text{Chord} = l + b. \end{array}\right.$

23. $w'' = O - a$ $\left\{\begin{array}{l} \text{For class II, wheels UNEQUALLY spaced. O being the ordinate computed by formula 13,} \\ \text{putting } p' \text{ and } p'' \text{ equal to the respective intervals between the axle centres for chord} \\ \text{equal to } l + b. \end{array}\right.$

29. $w''' = O' - a$ { For class III, O' being the ordinate, computed by formula 13, putting p' and p'' equal to the respective intervals between the axle centres for chord = J M.

27. Chord J M $= (\frac{1}{2} + b + c + f + f')$

X = ADDITIONAL SPACE REQUIRED BETWEEN GUARD AND STOCK RAIL.
This quantity should be computed by the rules on page 119.

THE CAIRO BRIDGE AND TERMINAL FACILITIES.

S. F. BALCOM, OF CHAMPAIGN.

The work on the Cairo Bridge has been reported in detail at our previous meetings, and in presenting the subject as a whole, now that it is completed, it will be necessary to review somewhat the matter already given.

First, a word as to the necessity for a bridge at that point. From a road extending from Cairo to Dunleith, with a branch from Centralia to Chicago, the Illinois Central Railroad now extends from Chicago to New Orleans, a distance of nearly 1,000 miles, which, with its main branch starting at Centralia and extending to Sioux City, a distance of nearly 700 miles, and an important branch connecting Chicago with its western line, and with its branch lines in the cotton and lumber sections of the south, and the fruit and grain sections of the north and west, makes in all a total of about 3,000 miles of road; and enters more states of the Union than any other railroad system.

During the last fifteen years its southern business has increased very rapidly; as, for instance, in the fruit line, shipments of bananas increased from eighty car loads in 1880 to four hundred car loads in 1888.

At first a transfer boat holding ten freight cars was put into use, and in 1884 transfered 61,700 loaded freight cars, and 8,000 passenger cars. The business steadily increased, and a transfer steamer holding sixteen cars was built and put into use.

The need of a bridge was constantly felt, but several obstacles stood in the way. It was known that nothing but a sand and gravel founda-

tion could be had, for no rock stratas could be found at a less depth than 200 feet. The river trafic would require a high bridge, and the swamps that extends for miles in all directions would necessitate expensive approaches in addition to high piers. When it was proposed to build the bridge, the river interests insisted on its being placed fifty-three feet above high water, as some boats have pilot-houses even higher than that—the Thomas Sherlock of Cincinnati, for instance having a pilot-house fifty-seven feet above the water-line. They also required that the channel span be not less than 500 feet long, to accommodate large tows of coal. In order to meet these requirements one-half million dollars extra expense had to be incurred.

Topographical surveys were made to establish the direction and velocity of the currents at low-water, high-water and at medium stage. The result showed that the current maintained almost exactly the same location at all stages of water in the river, which is a very favorable feature; for otherwise there would be considerable danger of scouring in the river bed around the piers.

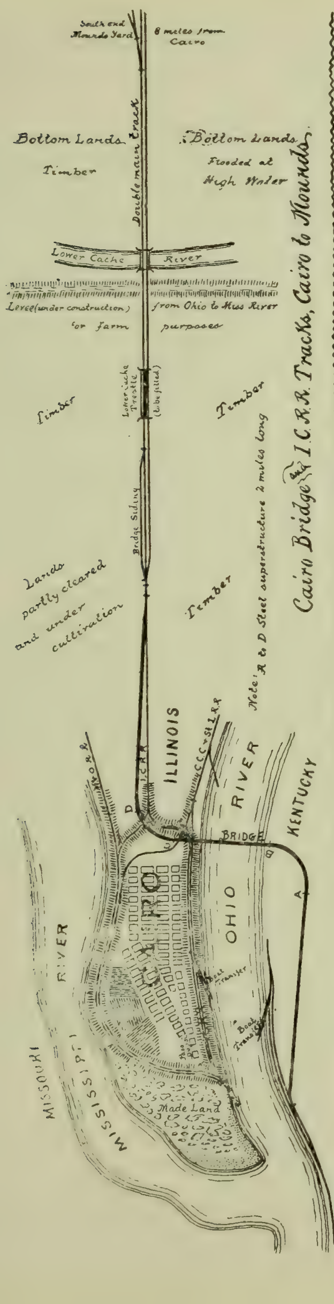
A base line was carefully measured by the corps of engineers who were placed in charge of the work, the south end of which was on the bridge line, and an observation station was erected at each end. The Union Bridge Co. was awarded the contract for the bridge proper, which was to cover a length of 4,650 feet, all of which was to be on a level grade and fifty-three feet in the clear, above high-water line. Anderson and Barr took charge of the foundation work and placed the first caisson in position in September, 1887. The foundation for the channel piers were made thirty feet wide and seventy feet long, consisting of a caisson sixteen feet in height, surmounted by thirty-four feet of timber work or cribbing, filled with concrete. Considerable trouble was experienced in sinking the foundation pier No. 9, of the east channel span. A sudden rise in the river brought the water above the cribbing, and to protect the shaft leading to the air lock, a bulkhead or nosing was built of timber and bolted to the up stream end of the crib work, and as the water rose, this timber protection and the air-shaft of boiler plate iron was continued up. At this time some extreme cold weather came on, and I remember going out to the work with the resident engineer when the temperature was below zero. The air and water pipes and all parts exposed were coated with ice, and the water in the river was seething around the shaft, the top of which was but a foot or two above water. There are times when work in such places has to be done at a terrible risk and still no accidents happens; and on the other hand horrible accidents occur when no danger seems near, as in the recent disaster at the Jeffersonville Bridge, where several men were drowned in one of the caissons. For fear of scouring, which might shift the caisson out of position, work was kept up as long as possible, and the danger, perhaps, can be more fully realized by the following extract taken from a report read at the last annual meeting of the American Society of engineers, of work under similar circumstances at the Van Buren, Arkansas, bridge: "Concrete in crib

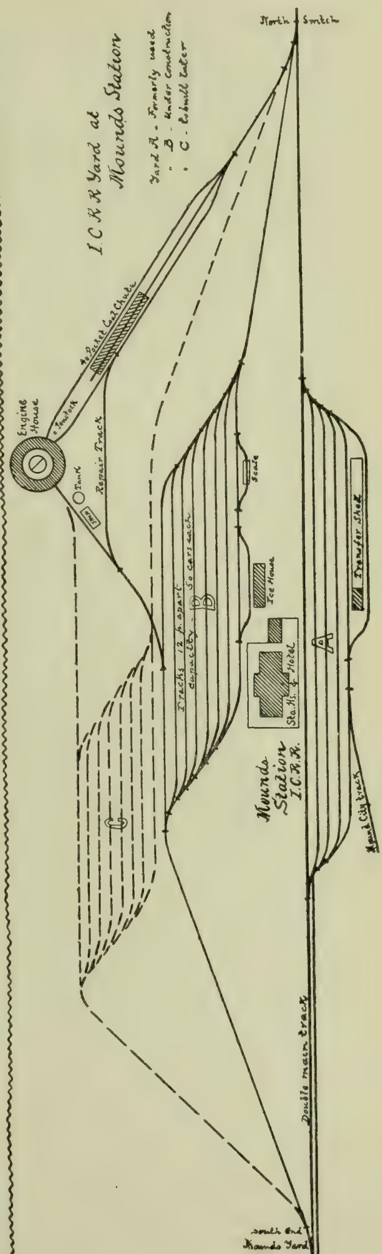
of pier No. 3 was begun and continued until a rise in the river scoured the sand out from the up stream end of the caisson; to protect it a row of piles were driven across the stream about fifty feet above the caisson, and brush cut and weighted down with stone above. The caisson was now a good deal out of line, the up stream end being low. When the river had fallen a little, the pressure barge was brought over and air put on and a part of the false bottom got out, but the river again began rising and the air had to be taken off and the boat moved away as she was in danger from the heavy drift running. So much drift caught on the piles driven to protect the caisson that they broke off, and the mass of drift coming down against the air shaft (the caisson and crib being under water) broke it off at the top of the crib, and the upper section containing the lock was lost in the river." What a horrible death trap this would have been had work been in progress!

At a depth of fifteen feet below the bed of the river, at the pier No. 9 mentioned, a large tree was encountered extending the full length of the caisson, and at a depth of twenty feet another tree was found under the north end of the foundation. Work was, in consequence, delayed, and the high water spoken of came on. The square end of the crib work offered a strong resistance to the current and formed an eddy or under current that scoured out the bed of the river, some sixteen feet deep and two feet lower than the bottom of caisson. Sand bags and rip rap were used, and the excavation, which previous to that time, had been discontinued, was resumed and the foundation lowered and shifted into its former position. At some high stages of water, the caisson work was carried on at a depth of ninety feet, at which times the heat was almost unendurable and a plant for forcing cold air into the caisson was introduced and the temperature thereby lowered some forty degrees. Louisville cement was used for concrete work and Portland cement for laying stonework and in ceiling the caissons. Series of tests were made of each consignment of cement and a tensile strain of seventy-five pounds per square inch was required in winter, and one hundred pounds in summer for Louisville cement, some consignments of this cement were found defective, but that of Portland seldom gave a result less than four hundred pounds per square inch.

Stone work, in charge of Loss and Wilson began in October, 1887, as soon as fifty feet of the timber and concrete foundation of first pier was ready. On this foundation about eighty feet of stone work was placed, which carried the pier above high water line; of this twenty-five feet is below low water line. This portion of each pier has pointed ends and is constructed of light colored limestone from Bedford, Indiana, the up stream edge or nosing being of New Hampshire granite.

Above high water line the piers are built up fifty-one feet with the ends rounded. This with the portion having pointed ends already mentioned, makes a total height of stone work in the piers of over one hundred and thirty feet, which, with the foundation, gives a height of about one hundred and eighty feet from the bottom of foundation to the top of pier.


Cairo Bridge & I.C.R.R. Tracks, Cairo to Mounds
Note: A to D Steel superstructure 2 miles long
South end Mounds Yard
8 miles from Cairo
Bottom Lands
Timber
Bottom Lands
Flooded at High Water
Double main track
Lower Cache River
Levee (under construction) from Ohio to Miss River
for farm purposes
Timber
Timber
Bridge Siding
Lands partly cleared and under cultivation
Timber
ILLINOIS
OHIO RIVER
KENTUCKY
BRIDGE
OHIO
CAIRO
MISSOURI
MISSISSIPPI
RIVER
Made Land
Boat Transfer


I.C.R.R. Yard at Mounds Station
Yard A - Formerly used
" B - Under construction
" C - to build later
North Switch
40 Pocket Coal Chute
Engine House
Tank
Repair Track
Scale
Ice House
Tracks 12 ft. apart capacity 50 cars each
B
Sta. Hs. & Hotel
A
Transfer Shed
C
Mounds Station I.C.R.R.
Mound City track
Double main track
South End Mounds Yard

The shore piers for the bridge proper are built of Bedford stone on pile foundations, and the piers for the approach spans are composed of boiler plate cylinders filed with concrete. Each cylinder is eight feet in diameter, two being used for each pier.

The erection of the steel superstructure was begun by Baird Brothers in July, 1888, with the erection of the two deck spans at the west end of bridge. In the following September, false-work, consisting of three stories of framed bents on pile foundation, for the west channel span was started, and had been completed about half way across the span when drift lodged in the pile foundation, and a sudden rise in the stage of water lifted and broke off the piles which had been driven some twenty feet into the bed of the river, and swung the whole mass around next to the shore. It was rebuilt, and after the erection of the ironwork the framed bents were transferred entire, by boat, to the next span.

The erection of the east channel span was the fastest on record for a long span, being done in forty-four working hours. It is five hundred and eighteen and one-half feet long, twenty-eight feet wide, and sixty-three and one fourth feet deep over all, and weighs 2,055,200 pounds. It is two hundred and forty-three feet from top of bridge to bottom of pier foundations, and the weight of the channel span added to that of the piers and other loads, makes the pressure at the base of foundation three and one-half tons.

The bridge proper is 4,650 feet long, in addition to 3,256 feet of iron work in south approach, and 2,656 feet of ironwork in the north approach, which makes two miles of iron, or rather, steel superstructure, weighing in all 11,000 tons, and is one of the longest, if not the longest bridge in existance. The remaining portions of the approaches 9,830 feet in length, are made of pile and framed bents, which will be immediately replaced with earth embankment. This, with the steel spans mentioned, gives a total length of nearly four miles for the bridge and approaches, and were completed ready for use the last of October, 1889, the bridge being formally opened October 29, 1889. A test was made by running nine mogul engines, coupled together, over the bridge followed by a train of six cars with officers and employees, and citizens of Cairo. In September last, grading for about five miles of sidetracks at Mounds was begun, and it was expected that by engaging a large force the yard could be completed in a few weeks. But wet weather set in and for three months more unfavorable weather for work could not have been had, for the continued wet weather and the amount of rainfall has been without precedent, as far as known.

The Mounds yard is located on the first high ground met with out from Cairo, all land south of this being subject to an overflow as deep as twelve and eighteen feet at high stages of the Mississippi and Ohio rivers. It is situated eight miles north from Cairo passenger house, and four and one-half miles north of the junction of the north end of bridge approach and old main track. A second main track is to be graded from the bridge junction to Mounds, and a side track will also

be placed next to bridge junction. The plan of tracks in the Mounds yard is that of the improved yards of to-day, being in sets of tracks; the first set of eight tracks, holding fifty cars each, is now being constructed. These tracks are parallel and twelve feet apart, and are all the same length. At each end of this yard is a lead track 2,000 feet long connecting it with the main track. Soon as required, a second yard or series of tracks will be built west of the present one and it will have similar lead tracks at each end. In addition to the yard mentioned an independent track leads to a forty pocket coal chute and up an incline to the top of same. From this track two tracks are run to the engine house, passing on each side of the coal chute. In these tracks are placed cinder pits, and between them a penstock is placed for supplying water to engines. The coal chutes are supplied from cars placed on the elevated track mentioned. The engine house is also reached from a track leading from the south end of the yard mentioned. The engine house is to be circular, and fifty feet distant from a sixty-five foot turn-table; it surrounds the turn-table and has three tracks passing through it from the turn-table; it has thirty-seven stalls for engines. An ice-house two hundred and forty-two feet long has been built and arranged so that eight refrigerator cars can be iced at one time. The bridge junction is three and one-half miles north of Cairo passenger house, and to reach the latter all through trains have to go into Cairo, and then back out to go over the bridge. This makes seven miles additional travel, and as a portion of it is within Cairo city limits, it has to be run at a slow speed and necessitates quite a delay. It is not probable that this arrangement for New Orleans trains will continue any great length of time, although the Cairo newspapers are insisting that the I. C. R. R. charter requires them to run all trains into Cairo. This difficulty could be overcome, however, if necessary, by establishing a passenger station on the bridge, as a portion of the bridge is within the city limits. This would cause a stop on the bridge and also require passenger elevators as the bridge is fifty feet above the levee. Extreme measures of this nature, will not, in all probability be necessary.

The bridge complete is a remarkable one. First, for its aggregate length; second, for its channel spans, as they were the longest trussed spans erected up to that date; and third, for its foundation, it being the first large bridge built on a sand and gravel foundation. The only objection to be found is one which will probably manifest itself in years to come, when the traffic of the road has increased, viz: that it a single instead of a double tracked bridge.

THE ENGINEER'S VIEW OF LAND DRAINAGE BY SPECIAL ASSESSMENT.

R. R. BOURLAND, of Peoria.

1st. The Law, its objects, effects and requirements.

2d. Varied character of the work and the great benefits to be derived from the possibility of combined action.

3d. The methods of drainage on a large scale. Comparative cost, past and present.

4th. The duties of the engineer in charge; his relation to the commissioners; surveys required.

5th. Field for research in improvements in machinery used for these purposes.

I present this paper not as a full exposition of the subject of special assessment drainage, but simply a statement of some of my observations and experiences in connection with some work under this law; hoping to draw out a profitable discussion on the subject of land drainage.

1st. The Law—Its Objects and Requirements. The law is the outgrowth or development of the demand by individual farmers for an outlet through the lands adjoining theirs to a natural water course, (for waters accumulating on their own lands to their damage) and at first provided only, that one might, at his own proper expense drain across the lands of another, provided he followed a "natural water course" with his ditch or drain. This is now so changed and expanded that by concert of action, a number of men in a district needing drainage may be formed into a corporate municipality, have power to act with as much force and effect, within the limits of its objects, as can a township, village or city. That is, the proper officers of the district may subject the lands to a valid lien for taxes or assessments levied under the provisions of the law for the proper purposes of the district. Such municipality is formed by a court of competent jurisdiction, or by the local authority as designated by the respective enactments, and the original district embraces only the lands included in such petition, but the district may be enlarged by provisions which enable the commissioners to bring other lands into the district, by a proper showing of benefits accruing to such land by reason of the drains constructed or improvements contemplated. These new lands then become a part of the district and are subject to the assessments levied by the commis-

sioners or the condemnation jury as the case may be, as a corporation district may, if necessary, condemn a right of way for its drains. In this way lands may be drained across the lands which do not need drainage or whose owners THINK they do not. The law also permits works on a large scale by forming a municipal corporation which may borrow money to pay for the work, and may legally issue bonds to secure the money borrowed, virtually distributing the payment by the interested parties over a period of years. This enables the prosecution of systems of ditches of a size and comprehensiveness that could not be contemplated by individual efforts. The law vests great power and responsibility in the drainage commissioners: they determine the number location and dimensions of the drains or levies; they make the assessment of the lands, subject to approval of the court or other authority; they advertise and let contracts for the work or do it by "day labor" as they may elect, and the assessments are collected and disbursed under their direction. Hence, when a district has chosen commissioners it has, so to speak, given over itself into their hands; last but not least they have the choice of an engineer, or may elect to get along without one altogether. The requirements of the law then are:

1st. That there shall be a body of land to drain.

2nd. That the owners, or the number required of them, shall want to drain it.

3rd. That other lands adjoining shall not prevent the drainage because its owners do not think they need it.

4th. The work must be done under the supervision of the commissioners to their satisfaction.

2nd. VARIED CHARACTER OF THE WORK AND THE GREAT BENEFITS TO BE DERIVED FROM THE POSSIBILITY OF COMBINED ACTION.

The law provides for drainage by ditches or protection from water by levees—drainage for agricultural or sanitary purposes. Hence it covers a large field of engineering possibility it opens up opportunity for investigation of lands now lying apparently worthless, and for finding a hitherto unknown outlet for the water which renders the land valueless. In some cases land as productive as the richest land in the State has thus been discovered or created, and as soon as the work was completed the land stood ready for the plow. It took no lengthy process of time to transform the soil, the removal of the water was all that had to be accomplished.

It opens the field of protection by levee, hence, by implication, the protection of lands by lowering the level of a damaging stream by removing obstructions or straightening the channel (notably of such rivers as the Sangamon or the Mackinaw); the designing and location of levees in such shape as to protect the most land at the least expense and the least interference with the flow of the stream levied against; and the least tendency to hold or retain water on the land within the levees. All these are proper subjects of engineering study and are all questions

which are likely, under the law above outlined, to be disposed of when they arise, by a set of men entirely unversed in the theories or mathematics effecting the subject matter.

In some cases the expenditures of the commissioners have been made of little value by the attempt to ecomonize, to so great an extent as to lead to the making of long ditches of so little depth and capacity, that they accomplished little or nothing for the lands intended to be benefited, and the opposite extreme has been reached in some cases by making ditches of immence width and capacity, but of little depth, and therefore, but little drainage power. But experience is showing that to ecomonically drain large quantities of land, a system must be designed with knowledge of the surrounding circumstances and after careful surveys.

The great benefits of this power of combined action has been frequently demonistrated in our own state, and in our immediate vicinity, within forty miles of Peoria, ten thousand acres or more of land which seven years ago was worthless swamp is now under cultivation or being brought under cultivation as fast as it is possible to do so, and wherever that is the case, the land is readily saleable at from forty to sixty dollars per acre. This has been done at an average cost of about twelve dollars per acre, and by experience it is learned, that this cost can be materially reduced. There has not been so much progress in the science of leveeing, although people are fast learning that no half way measures in that line pays, and that a levee just to high water mark is a "broken reed" not safe to rely on, and that, (at least in the case of the smaller rivers levied on both sides), the levees themselves cause the rivers to rise to unprecedent height at freshet times unless some counterbalancing work in the way of channel clearing or obstruction removing is done. In the Sangamon river, it seems that the river rises with the added heights put to the levees, and just lately there has been some planning for clearing and straightening the river bed. It is well known what immence tracts of land lie within the levees along the Mississippi river in Illinois, Arkansas, Mississippi and Louisiana, and when the water once gets through the crevasses or breaks in the levees, how quickly the immense bottoms are flooded. If this immense body of water is to be provided a channel for, how evident is is that if the levees are to be the banks that they must be above highwater enough to provide place for this body of water which seeks room for itself outside the levied stream. These questions are vital to the efficiency of works done under this law, and hence, should be submitted to competent engineers before being decided. The levees along the Mississippi river in Illinois are being strengthened under this law, and the most productive lands of the state are thus taken out of the bed of "The Father of Waters."

3d. METHODS.—The drains and ditches of ten to twenty years ago were such as were made by shovel or scraper work, and by the necessity of the case, were small and badly located. A ditch cannot be made through a swamp, morass or bog with shovel or scrapers, and swamp land cannot be drained unless the chosen water course is through its

best natural course, and that is very sure to be the wettest land of all. But with the modern dredge system, drains can be made in any material except quick-sand or hard rock. The cost of these dredges has been so much reduced as to make them available for much smaller works than formerly, as only a short time ago a large capital was necessary to be a "dredge man"; now, the cost of machine is soon overcome and saved in the large amount of material handled at a very small cost, in addition to the possibility of making drains in places where it would be impossible under the old dry dirt handling methods. Neither the old "blind ditches", nor small open ditches, nor tile drains come within the scope of this paper, as they do not represent any special assessment plans, neither does the great sanitary drain for the City of Chicago and the Illinois valley. The first are on too small a scale to be affected by the law, and the latter is on so large a scale as to require "a law unto itself," which law has, fortunately, been framed under the supervision of some of the best engineering talent of the state, and after a very full and very public discussion of the case.

4th. THE DUTIES OF THE ENGINEER IR CHARGE, HIS RELATION TO THE COMMISSIONERS AND SURVEYS REQUIRED.

In case the commissioners elect to employ the services of an engineer, his position becomes that of advisor to the board. The commissioners must still decide all questions as before stated, but the engeneer must be the "balance wheel." The commissioners are, probably, in every case interested parties, as owners of more or less of the lands assessed and improved, hence, by the nature of the case have personal interests to protect in the location and design of the drains as well as in the lands. The engineer then is the sole unbiassed representative of the general interest, his reputation is at stake in the location of work so as to accomplish the best result at the least cost. He must therefor first inform himself fully as to the topography of the whole district and adjacent lands; as to the nature, comparative level and capacity of the various possible outlets, and as to the nature of the soil to be drained; also, as to all facts connected with former attempts to drain in the vicinity of the contemplated work. Then, after determining the best route for the ditches, his report to the commissioners may be very brief but to the point.

The object of the engineer's efforts should be, 1st—to put the water in the ditches at as low a level as possible and to move as little material in so doing; for which reason I should recommend designing deep and comparatively narrow ditches. 2nd.—to design a ditch which shall maintain itself, with the least possible expense for repairs. To do this it must have fall enough to "scour" the bottom, and the banks must have such a slope that they will not cave and so fill up the ditch, nor be so flat as to invite the growth of cotton wood, willow or such small timber as would obstruct the course of high water. Then considerations are additional to the general one—that the capacity of the drains must be sufficient to drain the surface of the country; on the bases of the usual rainfall, acreage and gradient of ditches. The Mason and

Tazewell county drainage district with an acreage of 20,000 has a main outlet of an average section of 400 feet, gradient 1 foot in 1,500, and this is ample surface drainage except under extraordinary conditions of rainfall, when the capacity of this large ditch is over taxed and the surface water is held back for a time. The Hickory Grove drain district (now being constructed) with 6,000 acres assessed and taking surface drainage from only a slightly greater area, will have a main outlet of 230 feet section and a gradient of one foot in 1,850. From observation of the territory I believe that will be sufficient, though I anticipate seeing that canal running "bank full" frequently. The question of slope, while it is important, is almost "out of our jurisdiction," because it is impracticable to handle a dredge bucket at such an angle as to make "any kind of a slope," and the contractors prefer making a ditch full width on top and much more than full width on the bottom (and only have the specified section estimated to them), to trying to conform to a slope even though it be only one to one. The question then arises, has the district secured full value when the specified slope has not been worked to if the ditch is full width on top, full (or more) on bottom and full depth? I should like to hear this question discussed. In the placing of the material taken out a sufficient berm must be provided for in the specifications, and required in the construction. Where the banks are left as nearly vertical as a dredge is sure to leave them, this berm should approximately equal the depth of the cut. If a proper slope is left so that the banks do not and will not cave, the berm may be reduced to a minimum of say five feet. In providing for surface drainage, openings through the waste banks must be left at proper intervals and at the natural outlets. This is so simple a matter that in general it is left to the discretion of the dredge manager, but if there is in contemplation the using of the new bank for road purposes, then these openings should be carefully located so that culverts may be used and the road grade thereby made continuous. An excellent road can thus be made at little expense for grading and with little or no extra land for right of way.

The surveys required by the law are only those necessary to locate the bounderies of the district and the lines of the ditches, but to determine these points properly there should be actual surveys to show the lands actually benefitted by the work, and to show the relative benefit accuring to lands lying at different levels with reference to the ditches. The practice is to assess the land, by governmental subdivisions, according to the distance of the several tracts from the lines of ditch, and in some cases these subdivision have been arbitrarily 40 acre tracts, (a whole "40" being sometimes assessed when only a few acres of it were low-lying or wet land). In the case of the Hickory Grove district, I "meandered" the line between the dry and the wet land, and the wet acreage only was assessed as shown by the map. In seeking to do full justice more minute surveys by contour should be made, and the lands all through the district lying above certain assumed planes should be brought to the notice of commissioners or jury and relieved proportion-

ally in the assessment. But this entails too great an expense for "engineering" to suit the ideas of the men in charge of such works generally.

5th. THE FIELD FOR RESEARCH in improvement in machinery used for this purpose is large and interesting to the mechanical engineer, and through the improvement we look for the developement of great tracts of land. What is needed is a dredge which can be readily transported if possible without being taken to pieces, or failing there, easily taken down and rebuilt; one which can work in a narrow channel and work quickly; one which can place material moved a good distance from the machine; and one which can cut at an angle so as to form a slope; one which can work "up stream" with the least possible work in order to dam the work behind, and one which can move itself forward in the line of its work with the least possible delay. Improvements are needed in the "speeds" or stakes which anchor the boat, fitting the anchors or feet to the necessities of the soft material in which the work is necessarily done.

The operation of the drainage laws of Illinois has added and is adding to the wealth, productiveness and prosperity of this garden state; it has in many cases made the wilderness "to blossom like the rose," and those who framed it with those who act under it are worthy of the reward which is promised him who makes "two blades of grass grow where only one grew before".

DISCUSSION.

In reply to a question if any dredges were in use that cut the necessary slope as the ditch was constructed, Mr. Niles explained and illustrated a dipper dredge that had been working in Champaign and Douglass counties, that cut depth, width and slope as it went along, and is called a dry land dredge.

President Elliott called attention to a photograph here displayed of a dredge that works up stream and cuts a slope of one, one and one-fourth, and one and one-half to one.

TOPICAL DISCUSSION.

It is the intention that this topical discussion shall give, without the formalities or completeness of an extended article, the judgment, experiences, opinion or custom of the members upon the topic in question.

The numbers follow in order from page 140, Fourth Annual Report.

No. 15.

What is the cost of repairs of railroad pile bridges? Also their average life before renewal? What is the number of feet of pile bridges on your road?

Mr. A. N. Talbot, of Champaign.—I have been able to secure some data on this topic, and hope that other members may enlarge the list of roads here mentioned.

On the Chicago, Burlington and Northern Railroad, 331 miles contain an average of 320 feet of pile and trestle bridges per mile—an unusually large amount. The cost of repairs per lineral foot, in 1888, was twenty-three cents.

On the Western Division (in Colorado) of the Atchison, Topeka and Santa Fe Railroad, pile and trestle bridges with oak piles will last from ten to twelve years, and their renewal costs from $6 to $7 per foot.

Through the courtesy of Mr. W. H. Earl, I am able to present the following summary of the cost of pile bridge repairs, excluding renewals, on the A. T. & S. F. R. R. in Central Kansas.

COST OF PILE BRIDGE REPAIRS FOR 1889.

SUB-DIVISION.	Miles.	Total feet of Bridges.	Feet per Mile.	Total Cost.		Cost per foot	
				Labor.	Material.	Lab.	Mat'l.
Main Line......	168	2639	15.71	$593.62	$185.08	.225	.07
Branch Line.....	99	6655	67.22	361.92	127.73	.054	.019
Branch Line.....	30	3225	107.50	28.77	....	.009	......
Branch Line.....	233	28660	123.00	920.01	195.67	.03	.2006
Branch Line.....	84	5250	62.50	503.20	91.55	.096	.012
Branch Line.....	156	10180	65.26	754.19	164.16	.074	.915
Branch Line.....	46	2892	62.87	162.50	40.10	.056	.014
Totals........	816	59501	72.9	3324.31	804.29	.056	.0135

Above does not include some repairs from wrecks and fire; supervision included except engineering; second-hand material largely used; estimated at $10 per M.

In connection with this he says: "Whenever a bridge needs extensive repairs I renew it using the old material elsewhere; none of the material is wasted; it is all worn out in one way or another. The best of it goes to repair other old bridges, then when they are renewed, all the material is old together. Of course if we had no use for the material, this plan would not be economical; but we are oftener short of second hand bridge stuff than we have a surplus. We estimate the value generally at $10 per M. We renew our pile bridges when seven to ten years old, mostly from eight to nine years. Piles generally go first and there are generally helpers along side of piles by the time we renew. Sometimes where a bridge has a good top and not over sixty feet long we put in new piles and caps, then move the entire top to fit. Longer than sixty feet top has to be taken to pieces.

I now require a systematic inspection of every bridge in all its parts as often as once in thirty days. The inspector enters in a book each bridge number, date and condition, noting in detail any defects; signs book at end of trip, sends it to the general foremen, who in turn sends it to me. I copy the notes and date of inspection in my office bridge books. I have two general foremen and it takes a man under each about twenty days to get over the division. In addition, section foremen have track walkers examine bridges daily for broken stringers,

that being the only thing liable to give out suddenly. We still have a good many stringers split from the shoulder, generally a bolt put through makes them all right again. I think you will admit that we don't take many chances on bridges."

No. 16.

What is the average length of life of ties on your road? At what cost will a preserving treatment be economical?

Mr. Balcom, of Champaign.—The average length of ties is something over nine years. At a cost of 32 to 34 cents per tie, which is the price they cost the Illinois Central road, they are so cheap that it will not pay to treat them to any preserving process. Iron service plates on the tie prevents cutting by the rail and would be safer also by keeping the rail from topling over.

Mr. Hill, of Cincinnatti.—The United States Department of Agriculture has issued a pamphlet of 100 pages on the preservation of timber and discusses the drafts on our forests made by the consumption of railroad ties. The use of the iron service plate in theory is good, but in actual service it is like the old chair iron for rails, it rots from the dampness under it. Treating with good preservation increases the life of the tie three or four years. On roads with light taffic ties last longer than on those of heavy taffic.

No. 17.

What comparison is there in efficiency and in cost in your vicinity between the two methods of maintaining country highways,—"working out" the road tax, and that of tax in cash and trained labor.

Mr. Stanford, of Chatsworth.—In the older settled portions of the country where the roads are mostly graded, the cost of maintaining the country roads by the labor system are but trifling except for

"superintending." The culverts and smaller bridges are usually put in with road labor, but aside from these the work amounts to but little and is performed something like this: Sometime in August the "Overseer" goes around over his district and sees all against whom he has a tax, and asks them when they can work it out, usually stating a time within which he would like to have it done, and they also usually agree where the work shall be done. He also tells them what tax they have to work and when and where they can find scrapers which are usually furnished by the town. If the laborer owns a farm he usually mows the weeds along his own land in the highway, and if there is a road ditch he wants deepened for the better drainage of his farm, he does some good work deepening it, but he usually leaves the waste taken out on the road bed is such shape as to cause some profanity from the traveling public. But if the laborer has no personal interest to look after, he generally manages to spend six or seven hours a day resting himself and team, and INJURING the road until he has WORKED OUT his tax. I do not think this method can be made efficient, and the only, or rather the greatest reason why it is continued is, because the people know that the cash system will cost them more and they have their doubts about its being more efficient.

The cash system COULD be made efficient and as cheap as the other if we could have trained labor that we could employ, and officers who knew how economically to maintain our country roads.

Mr. Whittaker.—The commissioners who have tried both methods say that they can do more than twice the work for $100 cash than for $200 tax; can get better work done and where it should be done.

In May and June when most of the work should be done the farmers are busy and will put off working the roads till they have time, which is sometimes late in the fall or the next year. If he works he will work where he thinks it will do him the most good; but with the cash system the commissioner has to show by his work that the money has been used where it would do the greatest good. The result is better graded roads, more permanent bridges and better satisfaction to the tax payer and the public generally.

Mr. A. N. Talbot, of Champaign—As an example of the increased efficiency of the cash system over the labor system, I may mention the experience of a township in DeKalb county. Until a few years ago the method of "working out" the road tax was followed, and the roads re-

mained in the unsatisfactory condition which is found with the black soil and level surface of so much of our Illinois prairies. The roads were not improving, every year leaving the grades and drainage about where they had been, and no effort was made to improve the surface. Advantage was finally taken of the law allowing cash road tax. A competent superintendent was appointed and trained labor was employed. A system of improving the main roads of the township was begun, gradually reaching the less important ones. A coating of gravel was spread over a narrow road-bed—an earth track being left at one side. The average haul of the gravel was three or more miles. As a result, the township by an expenditure of $400 to $500 per mile for graveling, has secured fairly good roads, and the tax has been no greater than it was in preceding years. The same results have been attained in many a township where gravel is found at some point within its borders.

Before Illinois secures good roads some such method must be followed. The farming interest must awaken to the necessity of good roads in this day and age of the world, and I hope that this society will lead a movement in securing such a result.

Mr. Burnham.—The highway commissioners of McLean county had a convention a short time ago, at which it was stated that twenty out of twenty-eight have the labor system. The labor system saves the farmers from paying money tax which to some of them is objectionable. I know places where the farmers actually work out much more than this rate, where they are interested in a special piece of road, and in most places, I think in Southern Illinois, they would rather work out a twenty cent tax than pay in cash a ten cent tax.

No. 18.

What is the best method of perpetuating corners which fall in graded roads?

Mr. Loring.—A granite rock or boulder, not less than thirty (30) inches long, set on end, small end up with a small drill hole not less than one inch deep for center, with a witness of same description placed at an angle of forty-five degrees from north and south at given distances from said center. Said rock to be placed level with the surface. Record should show length, thickness and width of each rock.

Mr. Whittaker.—I set stones at the side of the roads when I can get them, the center of a well, trees or anything I can get, sometimes, in graveled streets I use three-fourth inch iron pipe fifteen inches long.

Mr. J. L. Clark.—I have of late, on account of its convenience, been driving an iron rod three-fourth inch or inch in diameter, and long enough, generally two feet or three feet, to render impossible the moving of the base, and carefully getting it plumb, and driving till the top is just below surface. On account of the trouble of unearthing in frozen weather, I have also set witness rods, generally setting them diagonally and equal distance from the corner, so as to readily detect any difference in chains.

Mr. D. L. Braucher.—In surveying in our county in 1866, I had occasion to establish a corner. Stones were scarce and I drove a stake and then set over the stake a piece of cast iron stove. I had occasion recently to look the corner up and fond only a batch of rust where I placed iron. Is iron a good thing then to put at a corner for a monument?

Mr. Niles.—Road makers usually cover up the corners. Witnesses should be placed so they could be easily found.

Mr. Balcom.—Mr. Niles is right. The witness stones should be placed at the corners of the intersections or near them.

Mr. Davison.—An iron stake is objectionable in a road. In case the road is muddy horses are liable to injury in stepping on them.

Mr. Burnham.—Mr. Cautine of Bloomington used slack coal.

No. 19.

What are the functions of surveyors in reference to plats and re-subdivisions of city lots as given by Chapter 109 and by paragraphs 62 and 63 of Chapter 120 Revised Statutes?

Mr. Jones.—In reference to Chapter 109 of the Revised Statutes I find that in re-surveying plats and sub-divisions there are many defects in them, arising from the fact that the original surveyors did not perform some of the duties prescribed.

I like the Michigan method of having an inspector of deeds. Plats are to be submitted to him drawn to a scale, and it is his duty to examine plat and discriptions, etc.

In twenty three plats which I have lately examined thirteen were defective. The defects were in not closing in properly; reference to monuments not good enough, lack of adequate description; imperfect certificate of survey, and the greatest of all a faulty certificate of dedication by the owner. In sub-divisions especially, no reference is made, quite often, to the original lines.

Mr. Bourland.—I think the functions of the surveyor in regard to sub-divisions are exagerated. His duties are to the man who employs him. He turns his work over to his employer. I am sure it would be a good plan to have a board of authority to pass upon it. It would be easier for the surveyor to convince the owner of the necessity for a certain amount of work which the owner often believes to be a waste of time and an extra expense to put in.

Mr. Niles.—I take it the functions of the surveyor is to do for the owner what the law requires to be done so far as his work is concerned. If he does less than that then he is at fault, if the owner does less than his duty the fault is his and he should bear the consequences.

Mr. Bullard.—You know the story about the man who paced the floor all night worrying about his debts which he was unable to meet, and the suggestion of a friend who said he ought to let the other fellow do the worrying.

I believe that every surveyor ought to do his whole duty as prescribed by law, and if the law does not cover the case he ought to be governed by justice and equity and after all rest quietly about it. If men will employ careless or incompetent men to do their work and accept bad work and afterward get into trouble about it, don't you do the worrying but let him tramp the floor. If he asks you to help him out then help him out but let him settle the bills. Its his matter,—some men will learn only by experience.

No. 20.

In letting contracts should the lowest bid always be accepted, and if not, what other feature should influence award of contract?

Mr. W. D. Clark.—To the first clause I emphatically answer, no! Tenders are often made be irresponsible parties for a sum much less than the works, of whatever nature, can be executed. In almost

all contract work there are contingencies to be taken into account, and the contractor is fortunate if he completes his contract without some unforeseen contingent adding to the cost of execution.

To the last clause I answer, that all works, either public or private, should be accurately estimated, adding a fair profit, say twenty per cent. Tenders often take a wide range, sometimes as much as two hundred per cent. between the highest and lowest bid, a result of inability on the part of those making the tender to estimate intelligently.

Were I to have absolute control I never would accept a tender for less than what I believe the works could be honestly executed, neither would I award a contract to any one except an honest or responsible bidder. Municipalities as well as corporations can better afford liberal prices and secure good work rather than cheap contracts and poor execution. In my experience I am never successful in securing the best work under cheap contracts, and have always been happy in the good fortune of having honest work when at good prices.

Mr. Burnham.—The question is too broad. It applies to the letting of all contracts, whether paid for entirely by public money and let by public officers, or let and paid for by individuals.

If entirely individual, private affairs, the common and common sense method of letting contracts, is to take the lowest bid when made by the most competent, most trustworthy and best equipped bidder. The lowest bid when made by an ignorant, incompetent, dilatory, or dishonest bidder, is not considered as being in any sense a bid, and is thrust into the wastebasket.

But in the letting of public contracts, it seems to me, there should be several methods of letting, each of which should be legal, each adapted to the different classes of public work, when classified in some rational manner. Specifications and plans accurately and properly designed, should be prepared by competent talent for certain classes of public work, and the letting should be publicly made to the lowest and best bidder, great care being exercised to confine the bidding to competent and trustworthy contractors, and the lowest bidder should have the contract in all these cases.

Other classes of work, particularly in small towns where full plans and specifications cannot readily be procured, should be let, as is often the case at present, by considering plans and specifications made by the bidder and filed with his bid, as being entitled to as much or more

consideration than the lowest bid, and an award should be made to the lowest and best bidder, taking into account plans, prices, competency, honesty and equipment for doing the work.

The whole subject is full of perplexity. Awarding always to the lowest bidder ensures that the job will very frequently go to the ignorant low bidder; the bidder on the verge of bankruptcy, anxious to keep up appearances till better times, or to him whose chief end it is to cheat and swindle in carrying out the plans. Honest contractors stand very little chance under this system, and would all be driven out of business if all of their work were secured in such public competition. If, on the other hand, full discretion were given to official to favor such bidders as their judgment approves, the way would at once be open for filling public offices with men who would never award a contract until their own percentage had been arranged for by rules of "addition, division and silence," and our last state would be worse than the first.

I see no present prospect of any improvement in methods, can give no light, assistance, aid or incouragement to reformers, if there be any, in this movement, but submit that I believe the subject worthy of our most carful consideration.

Mr. Baker.—It is certainly not best to award contracts always to the lowest bidder. There can be some rules applied to letting of contracts which if properly applied would not leave us in the helpless condition which Mr. Burnham pictures out to us. As applying to the last clause the CHARACTER of the bidder should be taken into consideration. If his character will not pass for general honesty, uprightness and fairness in his business his bid should be thrown out. Again the EXPERIENCE of bidders must influence largely the letting of contracts. Every man awarded a contract should have an intelligent understanding of what his contract involves, and if he does not his bid should be laid aside at once. The QUALITY of bidders may be next made a test. I mean their financial ability to conduct the work to completion in the allotted time. If one has not the means or cannot get the necessary financial backing, his proposal should not be considered. I think by applying the foregoing rules to all cases of letting contracts, very little trouble would be occasioned in getting the work well done for a reasonable amount.

Mr. Bullard.—My experience has been to always take the ability and character of the bidders into consideration when letting contracts, and have in the last few years, let quite a number of contracts

to other bidders than the lowest one. This is sometimes a delicate matter, but I usually announce before hand to the bidders that preference will be given to some men over others, and no bitterness or ill feeling is expressed generally.

No. 21.

What is the ratio of municipal engineering expenses to the cost of work designed and supervised.

Mr. W. D. Clark.—In Springfield the engineering is paid from the engineer's fund, and is not charged to public improvement, and unless the engineer keeps a special account of the time devoted to each branch of his work it would be impossible to make accurate estimates of the rate of cost.

In sewer construction a superintendent is employed at a stipend of four dollars per day which is charged in the assessment roll, and usually amounts to about four cents per lineral foot.

For block pavements three superintendents were employed, their salary being added to the assessment; one for the curbing, one for the grading and one for inspector of blocks.

Mr. Croswell.—In Kankakee it has varied from four to twelve per cent. The difference is due to several causes. The percentage I find larger on small contracts than on large ones. A smaller force is likely to be employed and requires nearly as much supervision as when a large force is employed. In sewers in wet trenches liable to cave, the visits of the engineer will be more frequent.

Some contractors require much more attention than others, at times from inexperience and again for other reasons. I find that most contractors, if their price is too low, require a closer supervision than when the price is fair. When price is too low, it is natural that the contractor should try and save himself, and involves an increased watchfulness, consequently increased cost for engineering.

I do not believe in letting work for less than a fair price, but when a contractor is financially good, and bonds good, in small cities it is difficult at times to avoid it.

No. 22.

What rule for distributing tax should be followed in special assessments?

Mr. Croswell.—I do not think any rule can be carried out fully. In Kankakee the city has heretofore paid all street work by general taxation. Property owners are required to construct and maintain sidewalks at their own expense. All main sewers have been paid for by general taxation; lateral sewers by special assessment. The practice with us has been, when the surroundings are nearly equal, to assess a uniform amount per front foot on adjoining property; sometimes assessing the city for catch basins and sometimes not. Our laterals are almost uniformily laid in the alleys; in some localities the buildings on one side of a block are on much higher ground than on the opposite side, and requires a less depth for sewers, the grade must be laid unnecessarily deep for the high ground to accommodate property on the lowest; again, to make perfect drainage and sewerage for deep basements of business property, it generally requires a lower grade than residence property. The business property being worth the most, and the cost of sewer greater to accommodate such property, it should pay more. Yet assessments based wholly on value of property and benefits are likely to create dissatisfaction and lead to litigation.

I think the best course is to base assessments on frontage where depths (or lengths) of lots are nearly the same; when they are not, make area a factor. Where a lot or series of lots require a much lower grade than the balance on account of deep basements or other causes, assess at least a part of such additional cost against such lots.

I find the best element of success in making assessments satisfactory to all concerned, is to see that the court appoints as commissioners none but UNPREJUDICED, IMPARTIAL and INTELLIGENT men.

Mr. Burnham.—There is a good deal of good sense in Mr. Croswell's remarks. He is careful to say to assess per front foot when lots are the same depth. In Bloomington that was never considered important. The main sewers to be paid for by general tax is hardly just, because parties living along the street in which they run may use them without cost.

Mr. Brauchner.—We are in the same difficulty in Lincoln about the justice of assessments for public improvements. With us it is usual to assess the city one third to be paid by general tax and the property two thirds to be paid by special assessment.

Mr. Wightman.—If we could only carry out the law as originally planned it would be all right. It is only a few years since the formation of the new constitution, and all this matter has grown up since then. It started in Chicago and after getting a decision or two of the Supreme Court in favor of these unjust ways of taxation, the Court has had to continue its decisions in the same line in order to be consistent, and to my mind, late decisions of the Court are in many cases wrong interpretations of the law, rather than interpretations reasonable and just.

After Chicago, then other cities took up the method of special assessments adopted there, until nearly all are now working under the laws as understood by the Courts.

REPORT OF EXECUTIVE SECRETARY AND TREASURER.

To the President and Members of the Society:

The following is the report of the Treasurer for the past year:

RECEIPTS.

Balance in Treasury, Jan. 23, 1889, -	$ 17 18	
Fees and Assessments, - - -	310 00	
Advertisements, - - - -	179 00	
Sale of Reports, - - -	13 27	
From G. P. Ela, fromer Treasurer, - -	13 00	
		$532 45

DISBURSEMENTS.

Printing Annual Report, - - -	$209 75	
Electrotypes, - - - -	5 36	
Circulars and other Printing, - - -	13 00	
Express on Reports, - - -	17 50	
Postage, - - - - -	42 82	
Stationery, - - - -	2 62	
Incidentals, - - - - -	4 45	
Salary Executive Secretary, - -	150 00	
Balance in Treasury, - - - -	86 95	
		$532 45

Approved:

GEO. F. WIGHTMAN, Members of Ex. Board.
I. O. BAKER,
C. G. ELLIOTT, Auditing Committee.

A detailed report of receipts and disbursements has been made to the Executive Board and may be seen by any one interested in it.

1050 copies of the Fourth Annual Report were printed by the Champaign Gazette at $1.25 per page for the first thousand. Copies were sent to the societies of Iowa, Michigan, Ohio, Connecticut, University of Michigan, The Dominion Land Surveyors. The exchange copies from these socities have been mailed to the members. A few remain and new members and any others who have not received these should apply to the secretary.

I congratulate the society upon its financial condition; yet far more upon *l'esprit du corps.*; which gives every promise of continued progress. The willing responses to requests for material for this meeting show a growing interest among the men of the society.

It becomes the sad duty of the secretary to report the death of three of its members:—Frederick Rottman, of LaSalle, Ill., who died June 6th, 1889; George W. Richards, of Carthage, N. M., who died May 15, 1889, and Henry T. Walch, of Buffalo, County Surveyor of Sangamon County.

A. M. TALBOT.
Executive Secretary.

REPORT OF THE EXECUTIVE BOARD.

To the Members of the Illinois Society of Engineers and Surveyors:

GENTLEMEN: Your Executive Board respectfully report that they have examined the accounts of the Treasurer and find the same correct.

The present Executive Secretary and Treasurer, Prof. A. N. Talbot, having signified to this board his desire not to be considered a candidate for re-election, this board desires to express to the Society its appreciation of the zeal, ability and success with which Prof. Talbot has conducted the work of his office for the past four years. In a very large degree the present flourishing condition of the Society is due to his earnest efforts. The Society owes him a debt of gratitude that can not be discharged by payment of salary. In view of the importance of the office and as a result of careful thought and investigation, this Board beg permission to recommend Mr. S. A. Bullard as a candidate for Executive Secretary and Treasurer.

In persuance of a requirement of our constitution, your Executive Board reports that they have fixed the annual assessment for 1890 at \$4.00 for old members, and \$2.00 for new ones, these amounts being the same as last year.

GEO. F. WIGHTMAN,
C. G. ELLIOTT,
I. O. BAKER,
} EXECUTIVE BOARD

REPORT OF COMMITTEE ON LAND DRAINAGE AND PUBLIC HIGHWAYS.

To the President and Members of the Society:

So far as is known to your Committee, no very extensive drainage schemes have been in progress in this state during the past year, but the excessive rainfall during the past summer has given great impetus to farm drainage with tile, and the most of the tile factories have been taxed to their utmost to supply the demand.

It would seem too, that land owners are putting in their tile with greater care, and the engineer has been more frequently called on to plan the work. The most giantic drainage scheme that has assumed shape since our last meeting is the drainage of the City of Chicago to the south-west through the Illinois River. This mammouth undertaking will be watched with much interest by the civil and sanitary engineer, both on account of the dificulties to be overcome and the many sanitary questions involved.

The season has been one to test very thoroughly the carrying capacity of our public ditches and tile drains in the central part of the state. As many as four different times during the summer, rain has fallen to the depth of four and a half inches in three hours to about six inches in twelve hours. The rainfall does not seem to have been so extremely heavy over any great extent of country at the same time, but sufficiently extensive to give us much valuable experience in the way of capacity required for drainage, and it would seem to prove that the sizes so generally adopted by engineers, viz: a carrying capacity of a half inch in twenty-four hours from the entire territory to be drained, is amply large for all purposes as long as the channel is kept clear, and but little if any too large.

HIGHWAYS.

During the past year but little has been done toward the construction of really good roads. We notice with pleasure an increase in the use of brick for paving purposes in many of the towns of our state, and also that another year has added to the proof that they are not only well adapted to paving purposes but economical to use as well.

In localities where gravel can readily be obtained, the use of that material has been continued. Pounded stone has also been used to a limited extent. Experience has shown that good roads can be made with either of these materials on our prairie soil, but not without much more than ordinary care. Of our dirt roads, which are the best in the world in dry season, perhaps the less said the better at the present time.

Thorough drainage either with open ditches, or preferably, with tile, and an occasional scraping with one of the many road scrapers that have been recently placed upon the market, is the best we can do for our dirt roads, and this, if properly done, will secure us good roads the most of the time, except where the travel is very heavy.

All of which is respectfully submitted.

D. J. STANFORD, Chairman.

THE REPORT OF THE COMMITTEE ON LAND AND CITY SURVEYING.

To the President and Members of the Society:

History records that the great Nelson said, that at his death "more frigates" would be found written upon his heart.

The devoted and conscientious surveyor asks for "more monuments." These are the be all and the end all of good surveying in town or country.

The initial point and the stopping place, plainly and unmistakably marked, binding in law and practice as they are, and so they ought to be, these and these only will save the surveyor many of the left-handed blessings he is apt to receive from his patrons. Good surveyors object to the expression "more or less" as regards areas, and justly think they should be at least able to give exact contained quantities, and scout the idea of there being any "ups and downs" on that point in the report.

There is, however, a place where the expression "more or less" properly belongs, and if used at all it should be used on the line. That

is to say, given that the two ends of a line are indisputable, say: "Beginning at south-east corner, perfectly identified, and running thence east straight to south-west corner, also well defined, one thousand feet "more or less." Here the ends of the line being fixed, the distance between them resolves itself readily into a matter of opinion.

A noted circuit judge said to an expert surveyor: "What is one thousand feet, is it a myth?" the answer was "Yes sir!" and in practice, so it is.

This use of more or less is the writer's practice, especially when describing sub-divisions by metes and bounds without actual survey.

A monument may consist of any name, no better described than, say; the south-east corner of a government sub-division, or of a block or a lot; even then it is a tangible thing, and even such a monument will often save the surveyor's credit, though not marked in the field.

HENRY C. NILES, Chairman.

EXHIBITS.

DRAWINGS.

The exhibit of drawings at the meeting was very extensive, many of them full of suggestions to the members. Mr. Balcom, chairman of the committee, explained publicly the drawings at one of the sessions, stating who made them, what each represented and when made.

It is very desirable that these exhibits be made as full as possible. Many interesting drawings lie rolled up in the members' offices that others would be glad to see. Bring them out when the chairman of the committee writes you about the exhibit for the next meeting, and send them or take them to the meeting with you.

A list of the exhibitors and drawings is appended.

List of Drawings Exhibited at Fifth Annual Meeting of the Illinois Society of Engineers and Surveyors.

W. W. Abell, Elgin, Illinois.

(1) Blue print maps of three additions to Elgin, Illinois.

(2) Plans for drainage and ventilating pipes for closets at Elgin National Watch Works.

(3) Plan for refrigerator or cold storage building at National House, Elgin, Illinois, including details for ice box, iron window frames, meat rack, etc.

R. R. Bourland, Peoria, Illinois.

Three blue print maps for farm dainage purposes, work done by stadia. Maps also show method of mounting and coloring blue prints.

C. G. Elliott, Normal, Illinois.

(1) One drainage district map.

(2) Several farm maps for complete drainage purposes.

(3) Photograph of steam dredge.

S. F. Balcom, Champaign, Illinois.

(1) Blue print map of Cairo and vicinity, showing location of I. C. R. R. Bridge and approaches.

(2) Blue print maps showing span of Cairo bridge, and blue print profile of river bed and ground in Illinois and Kentucky.

(3) Blue print plan of Mounds Yard.

(4) Blue print plan of "Hawthorne" Yard of C. B. & Q. R. R., near Chicago.

(5) Blue print map of the remodeled yard of Union Pacific R. R. at Denver, Colo.

(6) Large map of Centralia, Illinois, made by E. I. Cautine, member of Illinois Society of Engineers and Surveyors, showing elevation at street intersections for drainage purposes.

(7) Specimen of blue print profile work made from transparent profile paper. Also the following, secured by help of the Society:

(a) Maps of Alluvial Valley of the Mississippi river; eight large sheets mounted in two sections.

(b) Portfolio of thirty-two sheets, forming a map of the lower Mississippi River from the mouth of the Ohio River to the mouth of the Passes. Both maps made in Mississippi River Commission Office, at St. Louis, Mo.

(c) Collection of thirty photographs, mounted in map form, showing progress of work on the Cairo Bridge from its beginning to completion.

(d) Specimens of briquettes taken from tests of Portland and Louisville cement, also specimens of same cement after being put through the 100, 50 and 20 sieves.

E. A. HILL, Cincinnati, Ohio.

(1) Blue print of cross sections of ballasted track on Pennsylvania R. R., also Erie R. R., and on I. D. & W. R. R.

(2) Plans for station house on I. D. & W. R. R.

G. F. WIGHTMAN, Peoria, Illinois.

Sewerage map of Peoria, Illinois.

S. C. COLTON, Chicago, Illinois.

Plans of Washington street tunnel.

D. L. BRAUCHER, Lincoln, Illinois.

Plat showing workings in Lincoln Coal and Mining Company's mine.

E. L. MORSE, Cazenovia, Illinois.

Plans for railroad water tank.

PROF. I. O. BAKER, Champaign Illinois.

Collection of photographs of buildings, apparatus, etc., of the University of Illinois, from the collection sent to the Paris Exposition.

PROF. A. N. TALBOT, Champaign, Illinois.

Photograph of Hawksbury Bridge and sundry Engineering works.

Plan for C. M. & St. P. standard Pile Bridge.

DISPLAY OF INSTRUMENTS.

Messrs. A. S. Aloe & Co. of St. Louis made a most excellent display of their latest and improved Transits, Levels, Compasses, Drawing Instruments, Papers etc. They were thoroughly examined by the members, many of whom were careful to note the late improvements in all instruments they were specially interested in. One can hardly appreciate the differences between instruments made twenty-five years ago and those made at the present day, without the opportunity of examining them at leisure. The opportunity is afforded at these displays.

ANNOUNCEMENT.

THE SIXTH ANNUAL MEETING.

The Sixth Annual Meeting will be held in Springfield, in the last week in January, 1891. This was decided by the Executive Board after asking an expression from the members by a letter ballot.

The attendence at the Peoria meeting was not as well attended as most of the others, on account of the disease of *la grippe,* which was so prevalent in this country at the time.

We hope those who were disappointed in their plans to attend that meeting will be able to attend the next. The meetings should not only be valuable to the members, but the associations formed and acquaintances renewed or made will be enjoyable as well. Careful reports of the meetings can be read with much profit, but the pleasure of meeting old friends and forming new acquaintances, the social talk, reminiscences of other times, or novel experiences in other places, as well as the valuable oral discussions of the various topics, cannot be written down or be enjoyed in the reading. The only way to get the most out of a membership in the association, is to take advantage of the meetings of the association, participating in them with papers and discussions. Let every one attend the meeting in Springfield.

WHEREAS, Since our last meeting three of our fellow members Frederick Rottman, George W. Richards and Henry T. Walch, have been taken from us by death; and

WHEREAS, The Society has lost in the death of these members able and efficient members, and the State, honored and respected citizens; therefore,

Resolved:—That we as a Society tender our sincere sympathy to the families of the deceased in their sad bereavement, and

Resolved:—That a copy of these resolutions be printed in the Journal of proceedings of this Society, and a copy sent to the bereaved families.

D. L. BRAUCHER,
E. L. MORSE,
} Committee.